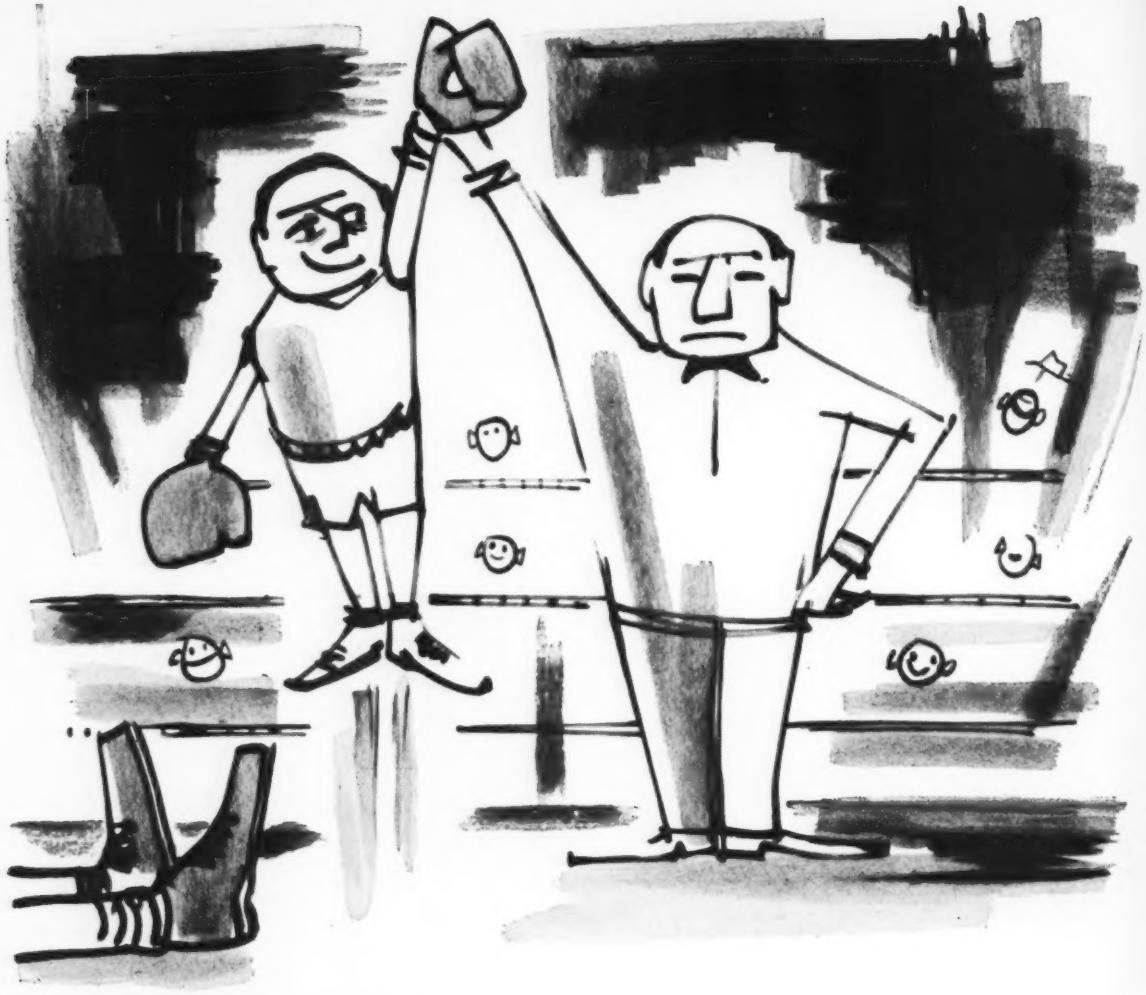
ngineering Materials and Design

THE UNIVERSITY OF MICHIGAN
JUL 8 1960
ENGINEERING

Hydraulic Stepless Transmissions *page 414*

EMD 3028 for further information



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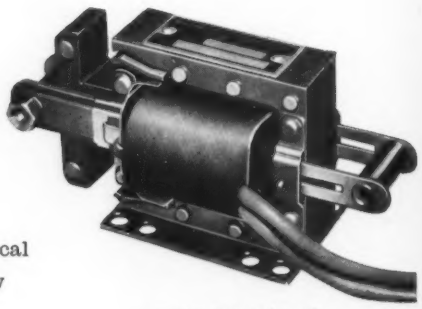

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Engineering Materials and Design

★ *The Magazine for Engineering Designers*

A HEYWOOD PUBLICATION

Vol. 3 No. 7 July 1960

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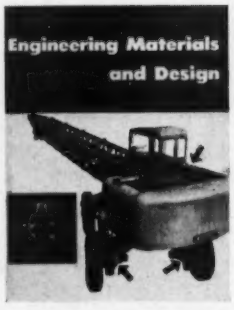

COVER: Hydraulic mobile crane using Staffa radial motors for winching, slewing and traction. Hydraulic jacks are used for luffing and extending the jib; fluid supply from three pumps driven by diesel engine. (Chamberlain Group of Companies.)

Published monthly by HEYWOOD & COMPANY LTD., Drury House, Russell Street, London, W.C.2 (Tel.: TEMple Bar 3422), on the 15th of the preceding month. Annual subscription 35s. sterling per annum ($5.25, U.S.A. and Canada) throughout the world. Single copies to order from all newsagents and bookstalls, 2s. 6d. each (by post from the publishers, 3s. 0d. each). BRANCH OFFICES: Royal Buildings, 2 Mosley Street, Manchester, 2, Tel.: Central 9935; Bayliss House, Hurst Street, Birmingham, Tel.: Midland 5786; 52 St. Enoch Square, Glasgow, Tel.: City 3492; 527 Madison Avenue, New York, 22, N.Y., Tel.: Plaza 9-1171.

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ISSUE AT A GLANCE

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By **D. A. Smith, M.Sc., A.R.I.C., A.I.R.T., A.N.C.R.T.**

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Résumés

CAOUTCHOUCS POUR USAGE À TEMPÉRATURES ÉLEVÉES

D. A. Smith page 398

Cet article étudie la nature et la constitution du caoutchouc et examine les effets des températures élevées. L'échelle des températures de travail du caoutchouc est divisée, par l'auteur, en plusieurs catégories ou bandes qui marquent les limites de l'utilisation pratique des divers types de caoutchouc. L'article discute les divers caoutchoucs, naturels et synthétiques, qui entrent dans chaque groupe.

PRÉSENTATION DES DOCUMENTS TECHNIQUES

F. Machon page 426

Pour de nombreux ingénieurs, la présentation correcte d'informations, rapports ou autres documents techniques devant être soumis à l'approbation d'une tierce personne ou servir de base de discussion est une source constante d'inquiétudes et de soucis. L'auteur propose quelques méthodes de présentation commodes et montre que la clarté est plus importante que le style dans ces conditions.

NIOBIUM ET TANTALE

T. H. H. Skeet page 422

L'auteur examine les caractères communs de ces deux métaux et leurs applications présentes et potentielles dans l'industrie, tenant compte de leur prix élevé actuel sur un marché sous-développé. Il donne les principaux usages de chaque métal sous forme de tables.

TRANSMISSIONS À VITESSES INFINIMENT VARIABLES

page 414

Seconde et dernière partie d'un article traitant des systèmes de transmission hydraulique à vitesses infiniment variables. La première partie a paru dans le numéro de juin.

EXPOSITION DES MACHINES-OUTILS

R. New page 406

Une revue des nouveautés et des tendances intéressantes notées dans le dessin des machines exposées au Salon International de la Machine-Outil qui a eu lieu à Londres, du 25 juin au 8 juillet 1960.

Kurzreferate

GUMMI FÜR HOHE TEMPERATUREN

D. A. Smith Seite 398

Der Artikel bespricht die Natur und Zusammensetzung von Gummi und untersucht die Einflüsse hoher Temperaturen. Die Skala der Betriebstemperaturen von Gummi wird in eine Anzahl von Gebieten oder Bändern unterteilt, die den Einsatz von verschiedenen Gummiarten kennzeichnen und die in die einzelnen Gruppen fallenden Natur- und Kunstgummiarten werden besprochen.

ENTWURF TECHNISCHER DOKUMENTE

F. Machon Seite 426

Für viele Ingenieure ist die richtige Darstellung technischer Daten, die Aufstellung technischer Berichte und anderer Dokumente zu Gutheissungs- oder Besprechungszwecken eine Quelle dauernder Sorgen. Der Artikel bespricht gewisse geeignete Massnahmen und zeigt, dass Klarheit unter solchen Bedingungen viel wichtiger ist als guter Stil.

NIOB UND TANTAL

T. H. H. Skeet Seite 422

Eine Untersuchung der bestehenden und möglichen Anwendungsgebiete dieser beiden Metalle in verschiedenen Industrien und ihre gemeinsamen Kennzüge, betrachtet vom Gesichtspunkt ihrer jetzigen hohen Kosten in einem unterentwickelten Markt. Die Hauptanwendungsgebiete sind in Tabellenform gegeben.

STUFENLOSE HYDRAULIKTRANSMISSIONEN

Seite 414

Die zweite Hälfte eines sich mit stufenlosen Hydrauliktransmissionen befassenden Artikels. Der erste Teile wurde in der Juni-Nummer veröffentlicht.

WERKZEUGMASCHINEN-AUSSTELLUNG

R. New Seite 406

Eine Uebersicht der interessanten oder neuen Züge in der Konstruktion of Werkzeugmaschinen, die auf der Internationalen Werkzeugmaschinen-Ausstellung in London vom 25. Juni bis 8. Juli 1960 gezeigt werden.

Резюме

РЕЗИНА ДЛЯ СЛУЖБЫ ПРИ ВЫСОКИХ ТЕМПЕРАТУРАХ

Д. А. Смит стр. 398

В статье обсуждаются свойства и состав резины и рассматривается эффект высокой температуры. Шкала температур, при которых резина может быть использована разделена на ряд категорий или полос, показывающих предел эффективной службы разного вида резины; рассматриваются входящие в каждую из этих групп виды природной и синтетической резины.

СОСТАВЛЕНИЕ ТЕХНИЧЕСКИХ ДОКУМЕНТОВ

Д. Махгон стр. 426

Многие инженеры очень озабочены вопросом о правильном изложении технической информации, докладов или других документов, подлежащих одобрению или обсуждению. Статья приводит удобную для этого процедуру, показывая, что в данных условиях ясность изложения важнее стиля.

НИОБИЙ И ТАНТАЛ

Т. Х. Х. Скит стр. 422

Статья рассматривает существующие и потенциальные возможности применения этих двух металлов в промышленности а также общие для них характерные черты в свете их высокой стоимости в данное время на недостаточно развитом рынке. Главные виды применения каждого из этих металлов приводится в форме таблицы.

ГИДРАВЛИЧЕСКИЕ БЕЗСТУПЕНЧАТЫЕ ПЕРЕДАЧИ

стр. 414

Вторая часть статьи о системах гидравлических передач с бесконечно переменной скоростью. Первая часть была напечатана в номере этого журнала за июнь месяц.

ВЫСТАВКА СТАНКОВ

Р. Нью стр. 406

Обзор интересных деталей и новинок в конструкции станков, показанных на Международной Выставке Станков, состоявшейся в Лондоне между 25-м июня и 8-м июля, 1960-го года.

MATERIALS IN THE NEWS

Monthly Digest of Materials and Design News from Home and Abroad

A specialist Exhibition and Conference

THE TREND towards engineering exhibitions of a specialist character, run in conjunction with a conference, was well exemplified by the 2nd European Fluid Power Conference which was held concurrently with the 1st International Compressed Air & Hydraulics Exhibition at Olympia from April 25th to 29th.

Most of the 21 papers delivered at the conference on Pneumatics, Hydraulics and Fluid Power were of a very practical character, in many instances being given by engineers from companies manufacturing such items as pumps, compressors, seals, actuators, valves, etc. Although at first sight this might seem to the academically minded person to give the conference a commercial atmosphere, it must be remembered that the great advances made in recent years in the application of compressed air and hydraulics have been entirely due to the intense competition between specialist manufacturers making the parts from which such a variety of special purpose machines and automation set-ups can be produced.

One exhibitor summarised the present position:—"A few years ago it was necessary for a salesman to explain the virtues of compressed air to the manufacturer about to make a special piece of equipment. Now the pattern is quite different. The immense possibilities are now realised by engineers who readily approach the many manufacturers of equipment. They know what can be achieved with it and are mainly interested in the special advantages of this or that valve system, etc." This new trend has greatly intensified competition and stimulated inventive ingenuity in recent years. The result has been beneficial to the user in that it has improved quality and variety and lowered prices.

The number of valves and actuators on display was both bewildering and fascinating, the interest shown by visitors being clearly of a very discriminating character.

Standards Engineers to form Association

A FIRM DECISION was taken by delegates attending the 1960 conference of standards engineers to bring together in an association all those concerned with the application of standards in industry. It was agreed that no separate organisation, as was earlier envisaged, should be set up but that standards engineers and others with a special interest would be able to become associates, on a personal basis, of the B.S.I.

It was agreed that associates would be organised on a regional basis to allow for convenience of meetings and that initially a fee of a guinea a year would be charged for B.S.I.'s services. Standards engineers wishing to participate in the associates scheme are invited to write to the Joint Secretary, I.Prod.E./B.S.I. Committee, British Standards House, 2, Park Street, London, W.1. An inaugural meeting will be held in London on July 8.

At the same conference Mr. N. A. McNeill, Chairman of Council of the Engineering Equipment Users' Association, in opening a discussion on making the best use of British Standards, made the point that there was a great need for promotion of British Standards amongst the smaller firms. The conference delegates represented almost entirely large and well-known companies and therefore to a large extent Mr. McNeill's remarks were addressed to the converted. However when it is realised that about 80 per cent of the companies in the London area employ less than 1000 persons and many of these organisations are working on sub-contracts from larger firms, it is obvious that there is still much ground to cover.

The B.S.I. came under fire regarding the length of time which seemed to be required for the preparation of specifications, but a useful suggestion came from Mr. O. R. Tucker, also of E.E.U.A., who proposed that the services of retired or semi-retired engineers should be employed on the committees, which could then meet more often than was the case at present. Committees manned by engineers at the peak of their active careers are undoubtedly hampered by the fact that meetings must be spaced out over long periods.

Mr. T. R. B. Sanders speaking on the inch/metric issue in international standards referred to the recently published report by the committees of the British Association and the Association of British Chambers of Commerce. Whilst a complete change-over to metric seems to be out of the question in the foreseeable future "decimal thinking" in inch sizes is recommended as a practical compromise.

Microminiaturisation at I.E.A. Exhibition

THE DEMAND for transistor circuits of improved reliability and smaller size has engendered at the Royal Radar Establishment a programme of research and development aimed at establishing techniques for use in microminiaturised transistor circuits. The immediate objective is to scale down conventional transistor circuits by at least 10:1 in both size and weight.

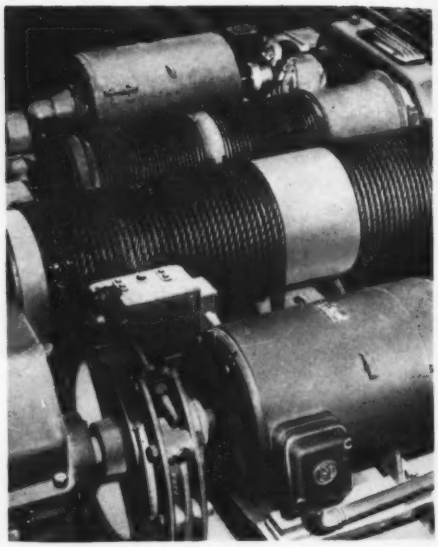
As far as possible, inorganic materials are used because of their greater stability and inherent reliability. At present the circuit substrate is glass, but ceramic is preferred and will be used if material with sufficiently smooth surfaces can be developed. The components are in the form of thin films deposited by vacuum evaporation. Resistors consist of nickel-chromium films about 75Å thick, which are processed to give values up to 100,000 ohms in an area 5 mm. square. Lower value resistors occupy a smaller area.

Capacitors are made in the form of a sandwich of thin metal films with magnesium fluoride as a dielectric, a capacitance value of 2,000*p*F at 25 V d.c. being obtained within an area 5 mm. square. The power factor of these capacitors is less than 1 per cent. Large value capacitors and inductors are difficult to miniaturise, but special circuit techniques can sometimes remove the need for this.

Two million components in a cubic foot are made possible by the use of transistor circuits of the type shown here.

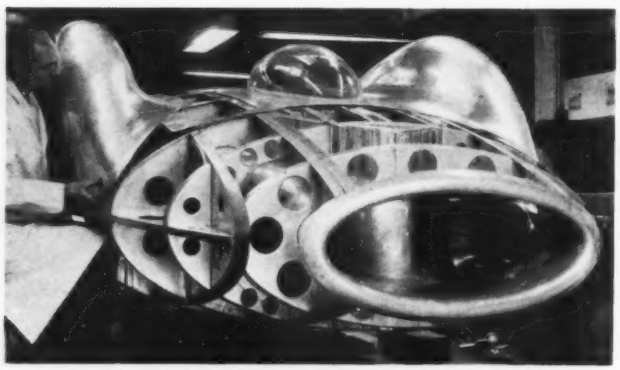
PICTURE NEWS

IN THE WORLD OF MATERIALS & DESIGN



CRANE BRAKING—OLD AND NEW

In the foreground the standard sheave type brake and in the background a De Bergue Discgrip brake on a 25/5 ton crane grab. This latter is one of a range of industrial disc brakes to be introduced later in the year by Ferodo Ltd.

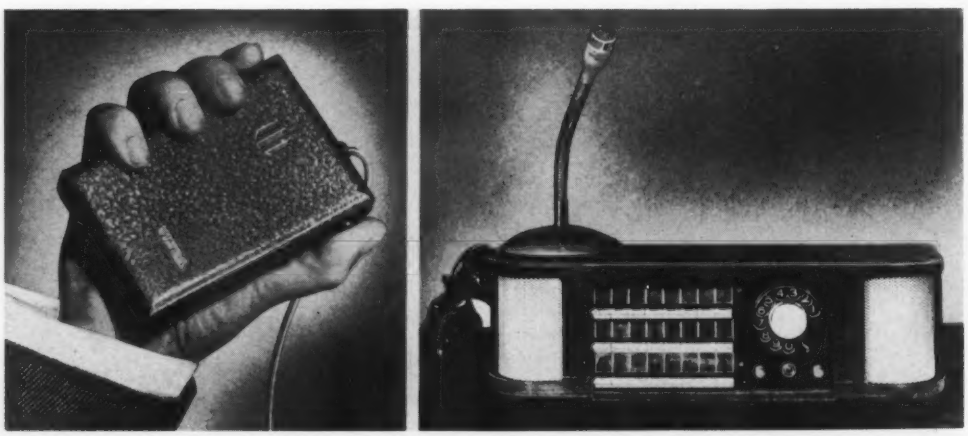


HONEYCOMB FOR HIGH STRENGTH STRUCTURE

The main structural members of Donald Campbell's record-breaking car are made from Aeroweb Honeycomb bonded between 18-gauge aluminium sheet. These are believed to be the largest aluminium honeycomb structures ever manufactured.

HIGH VOLTAGE TRACTION

G.E.C. 3,300 h.p. 25 kV electric locomotive on the London Midland region of British Railways. Designed for hauling 100-m.p.h. passenger trains, it is provided with automatic voltage selection equipment to operate on 6.25 kV when required.



RADIO PAGING SYSTEM

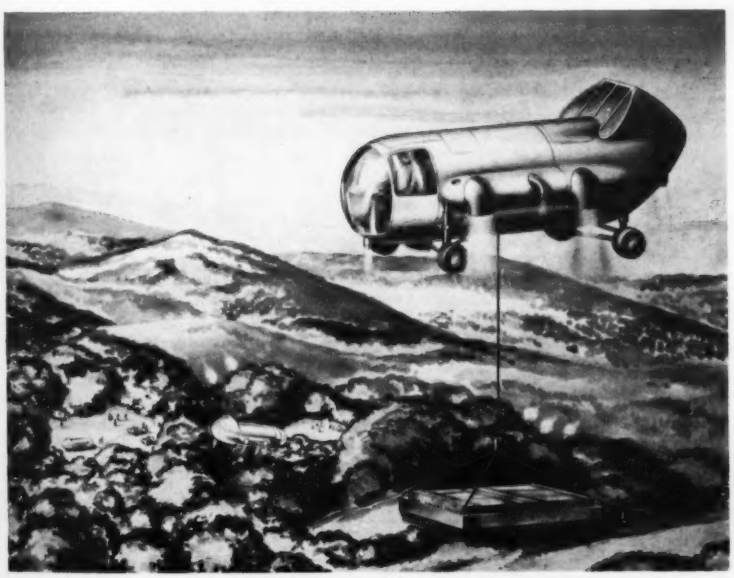
Ultra Electronics Ltd. exhibited at the I.E.A. Exhibition a new paging system for remote control of personnel. It provides for selective calling of up to 98 individuals with or without speech. The receiver (left) weighs only 14 ozs. and the transmitter (right) operates in the v.h.f. band.

AWARD FOR CAMERA DESIGN

The Design Centre Awards for 1960 included a Certificate of Merit for this Brownie 44A Camera made by Kodak Ltd. Back and side panels are of black plastic cloth and the ends are of polished plated metal. Including neck strap the camera weighs only $8\frac{3}{4}$ ozs.

UNIQUE DESIGN OF FIRE FLOAT

This B.P. Firemaster was designed by the B.P. Tanker Co. It is designed around two pontoons each 60 ft. long and 14 ft. wide and spaced 8 ft. apart; they are joined together at deck level by elliptical tubes to form a catamaran. The 40-ft.-high tower is built on four tubular supports.



FLIGHT WITHOUT WINGS

This design by Bristol Siddeley is made possible by the development of a gas turbine jet propulsion engine which can now produce a force of seven times its own weight. For low speed operation (say 200 m.p.h.) the vehicle can be simple and light so that with an engine weighing one ton it is expected that the capacity available for fuel and pay load would be about $4\frac{1}{2}$ tons.

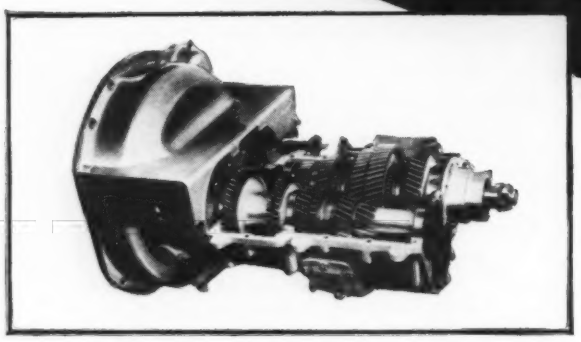
FLAW DETECTION

This equipment shown by the Sperry Gyroscope Co. at the I.E.A. Exhibition is called Introview and is based on the eddy current principle. It is used for non-destructive testing of non-ferrous metals, especially condenser and heat exchanger tubes, and it is also available for stainless steel.

E.M.D. 3107 for further information

NICKEL ALLOY STEELS

for long trouble-free mileage



TYPICAL CORE MECHANICAL PROPERTIES OF

EN36

3 per cent nickel-chromium-molybdenum case-hardening steel

SIZE	HEAT TREATMENT	MAXIMUM STRESS t.s.i.	ELONGATION per cent	IZOD ft. lb.
1½" dia.	Oil quenched 780°C.	72·0	19	69
2½" dia.	Oil quenched 860°C.	62·7	19	67
	Oil quenched 780°C.			
3" dia.	Oil quenched 860°C.	59·7	22	72
	Oil quenched 780°C.			

Additional benefits to be gained from the case-hardening nickel steels such as En 33, En 34, En 36 and En 39 include ease of heat-treatment, minimisation of processing distortion and general reliability.

Over a half-million miles and nineteen years of service have not impaired the efficiency of the David Brown gearbox fitted to this E.R.F. lorry operated by Samuel Drake and Sons Ltd., Honley, Huddersfield. During a recent major overhaul after 582,000 miles of running, the gearbox was found to be in excellent condition and was replaced for further service, with a rebuilt engine.

Throughout their range of gearboxes, the David Brown Automobile Gearbox Division, Huddersfield, employ nickel alloy case-hardening steels, types En 34, En 36 and En 39. These steels are used to ensure reliability of the gears and shafts under the heavy and sustained stresses encountered in their operation.

Please send for our publications entitled, 'The Mechanical Properties of Nickel Alloy Steels' and 'The Case Hardening of Nickel Alloy Steels'

MOND NICKEL

THE MOND NICKEL COMPANY LIMITED · THAMES HOUSE · MILLBANK · LONDON · SW1

TGA 21/1WA

Design contest in Stainless Steel

THE STAINLESS STEEL DESIGN AWARD COMMITTEE has sponsored an international exhibition of photographs of designs in stainless steel, under the auspices of the National Industrial Design Council (N.I.D.C.), whose headquarters are in Ottawa. In addition to conducting the exhibition, the N.I.D.C. is responsible for its design and for the appointment of the jury who will choose the award winning photographs exhibited. The purpose of the exhibition is to publicise excellence of design in stainless steels and to give recognition to the services offered by industrial designers and artists. It will be shown during September in the National Gallery of Canada and later in other major Canadian cities.

Fibres Strengthen Titanium Alloys

AS OPERATING TEMPERATURES increase in aircraft and missiles, there is an increasing need for titanium alloys that are strong enough to withstand service at these higher temperatures. The upper temperature limit for commercial titanium alloys has been 420 to 480 deg. C, although recently announced alloys are reported to be stable in the range of 540 to 590 deg. C. For short times, in the order of minutes, the present titanium alloys may retain their strength up to 760 deg. C. The retention of strength at about 650 deg. C. for long periods of time and the attainment of higher short-time strength at about 810 deg. C. would increase the usefulness of titanium in aircraft and missiles.

In the intermediate temperature range, up to about 425 deg. C. titanium can be strengthened by alloying and by suitable heat treatment. At higher temperatures, approaching and especially above the recrystallisation temperature, the commonly used strengthening mechanisms are ineffective and the strength of each of the alloys decreases to about that of unalloyed titanium.

In heterogeneous structures containing fibres, the composite structure of fibres and matrix is stronger than the matrix without fibres. In a heterogeneous structure containing dispersed particles, a somewhat different strengthening mechanism operates. The tensile properties of the particles themselves are less important than in the case of fibres as the presence of the particle hinders the movement of dislocations, and permits the inherent properties of the matrix itself to be used more fully. To accomplish this, there must be good bonding between the particles and the matrix. The dispersed particles also raise the recrystallisation temperature and reduce grain growth. Thus, the use of fibres and dispersed particles offers a possible means of raising the useful temperature range for titanium alloys, although no commercial alloys using fibres or dispersed particles for achieving strength are believed to be available yet.

Fibre reinforcement of titanium offers good promise for improving the short-time strength and modulus of elasticity in the temperature range of 540 to 760 deg. C. Both the strength and the strength-to-density ratio are improved when molybdenum fibres are added to unalloyed titanium and to the Ti-6A1-4V alloy. Samples of the Ti-6A1-4V alloy reinforced with discontinuous molybdenum fibres had a strength-to-weight ratio higher than either Inconel X or A286 at 650 deg. C.

Improvements in the long-time strength, as indicated by stress-rupture data, are not so hopeful. Problems remain of protecting the molybdenum fibre from catastrophic oxidation and of the tendency of the molybdenum to go into solution in titanium after long periods of time at high temperature.

Whereas fibre reinforcement looks promising for short-time applications, dispersion hardening with insoluble particles may be useful for both short-time and long-time improvement at high temperatures. Tests demonstrate the feasibility of dispersion hardening, but the optimum compounds and processing conditions have not yet been discovered.

Dispersion hardening with mechanically dispersed metallic particles offers little promise. If sufficiently fine particles are used to obtain strengthening, the solution rate of the particles in the titanium matrix becomes excessive. On the other hand intermetallic compounds, such as Ti_5Si_3, Ti_2Cu, and TiC, and oxides, such as CeO_2 or other rare-earth type oxides, show considerable promise.

Intermetallic compounds may become useful over various temperature ranges for certain purposes. Titanium with Ti_5Si_3 and Ti_2Cu dispersions showed good retention of strength between 425 and 650 deg. C. and may be developed into a useful engineering material.

The dispersion of oxides in a titanium matrix offers considerable promise. The actual improvement in strength obtained so far has not been so spectacular as in the case of aluminium from SAP.

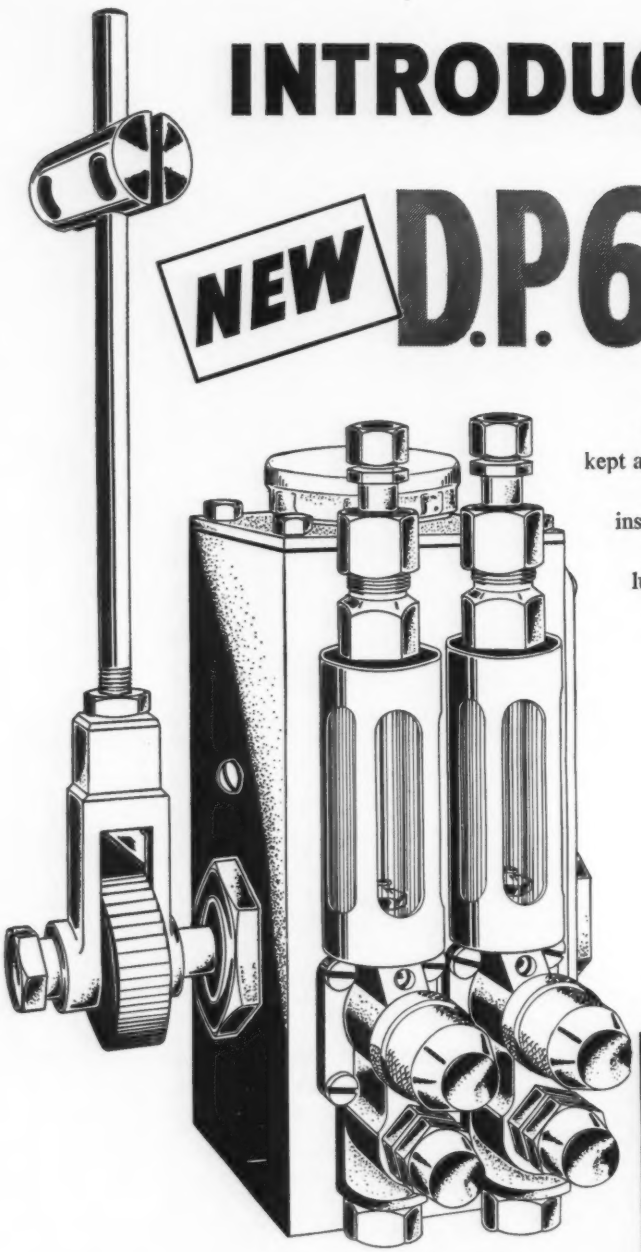
The General Electric's fuel cell power pack being developed for the American Services produces 200 watts at 24 volts and weighs only 30 lbs.

Fuel Cells versus Batteries

A MAJOR STEP which promises to place the fuel cell on a practical engineering level is the announcement by the American General Electric Co. of their ion-exchange membrane cell. At least 25 organisations in the United States and this country are said to be working on the development of fuel cells, but the ion-membrane fuel cell appears to present the advantages of most other cells presently available with none of their disadvantages. It operates at room temperature and pressure, and the reactions take place in contact with a solid electrolyte which consists of a plastic membrane permitting hydrogen ions to migrate from one electrode to the other. The cell is designed to use air instead of pure oxygen and the absence of a liquid electrolyte eliminates the need for pumps and storage containers. Water formed during the operation of the cell can drain away and this eliminates the need for an electrolyte separating plant required in other types of cell. An output of 100 watt hours per pound at a thermal efficiency of 60 per cent is claimed.

In spite of the fuel cell progress batteries are still fighting back. An interesting development is announced by The Three Point One Four Corp. who claim to have developed a chloride battery capable of delivering a current in the order of 10 amps per sq. in. of electrode area. A special feature of this battery is its rapid depolarisation. Full technical details have not yet been released, but a battery delivering peak currents up to 3,000 amps and measuring $1\frac{1}{2}$ in. dia. and 6 in. long is under development.

INTRODUCING THE NEW D.P.60 MECHANICAL LUBRICATOR



During the last 60 years, Wakefield lubricators have kept abreast of the changing needs of industry. The DP 60 represents the experience of these years. It is an instrument of precision for feeding oil against pressures up to 1,000 p.s.i. It can be operated by the plant it lubricates on reciprocating or rotating drive. The flow of oil is automatically controlled by the 'start-up and cut-off' of the machine. Efficient lubrication is combined with economy in oil consumption.

ADVANTAGES OF THE DP 60

Welded steel construction gives strength with low weight ratio.

Each feed can be regulated independently.

Complete pump unit can be removed and replaced in one assembly.

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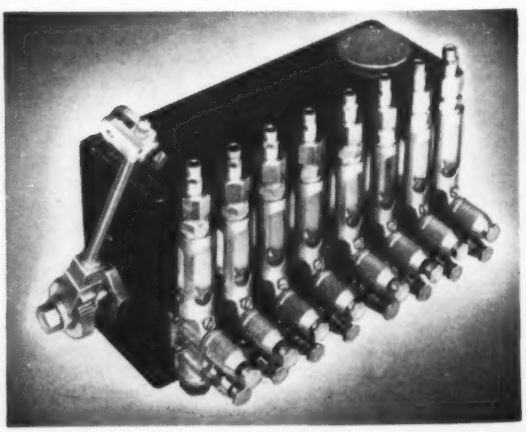

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Isotopes for Industry

THE OPENING on the 4th May of two radioactive laboratories at the Radiochemical Centre, Amersham, by Sir Cyril Hinshelwood, O.M., President of the Royal Society, followed by the opening of Wantage Research Laboratory within a week or so, has underlined the growing importance of the use of isotopes for medical, research and engineering applications. Whereas at the Radiochemical Centre the main emphasis is upon the development, production and marketing of radioisotopes, and the organisation there is now held to be the most comprehensive in the world, at Wantage Radiation Laboratories the main emphasis is on research into the fundamental properties of radioisotopes and investigation of their applications in such fields as plant breeding, pest control, and various industrial uses.

Although at present the output of radioisotopes for use in engineering is only about 20 per cent of the total quantity produced, the largest consumers being hospitals and research laboratories, this field is growing faster as the value of isotopes becomes better understood.

A notable exhibit at Wantage was a Package Irradiation Conveyor plant for the continuous irradiation of large quantities of materials, varying both in physical size and the irradiation doses required. This plant would appear to solve many problems in the medical and industrial fields where it is necessary to sterilise such items as blankets, food and drugs. An irradiation unit comprises a gamma ray source and machinery for the controlled passage of materials around it. This plant is being built for the Technological Irradiation Group of the Isotope Research Division, Atomic Energy Research Establishment by the Owen Organisation.

Of particular interest to the design engineer were various pieces of equipment developed at the laboratory, and in some cases now available in their production version from manufacturers. The Ekco Gamma Backscatter Gauge was primarily designed for the detection of small flaws or points of excessive corrosion on the inner or outer surfaces of pipe walls. The instrument is portable and light in weight, straps being provided to enable the indicator to be carried slung on the shoulder. A sensing head is housed in a pistol-like instrument, and comprises a sodium iodide crystal and an eleven stage photo-multiplier together with a small built-in source of Cobalt-60. Spring loaded jaws on the holder are so designed as to ensure correct location in respect of the object being measured.

When the measuring head is placed in position against the object to be gauged, gamma rays from the source impinge upon the object and a proportion of these rays are reflected back to the crystal. This backscattered radiation is converted to electrical impulses which are amplified and passed to the gauge circuits. The light weight of the instrument renders it particularly suitable for those applications where it is necessary to climb about amongst plant and machinery, as would be the case in shipbuilding, docks, oil refining, gas production and fuel pipe examination.

A Radioisotope Spectrometer for measuring tinplate thickness employed fluorescent X-rays excited by a radioactive source. The measurement of the thickness of such coatings on a sheet of iron is normally a difficult problem because a typical tin coating may be only 15μin. thick, while the iron is about 0.001 in. Thus mechanical, electrical, magnetic, X-ray or beta-gauge total thickness methods are ruled out. In the methods normally used, which are either chemical or electrochemical, the coating is removed from a known area and the amount of tin is determined either by the time taken to strip the tin electrochemically, by volumetric or gravimetric analysis or by loss of weight. These methods give an accuracy of about 1 per cent, but they are slow and cannot record continuously the changes in tin thickness which, in some plants is as high as 200 ft/min.

A method of measuring turbulent flow rates in pipes without any appreciable constriction of the pipe bore was also shown. A high speed injector is used to inject a small quantity of radioactive liquid into the pipe line. The time taken for this source to pass a scintillation counter situated further down the line is measured on a recorder.

Other examples of work carried out at Wantage, or using techniques developed there, included those using tracer techniques for such problems as the mixing of ingredients in glass manufacture, the detection of leaks in hermetically sealed components such as undersea repeaters, water pollution, leak detection in pipe lines, and the movement of pebbles in tideways.

Argon-Arc welding in a specially adapted shielded cell enables Cobalt-60 to be canned by remote control.

Toward Ductile Chromium

WELL KNOWN for its electroplating and chromising capabilities, chromium would probably possess even greater potential usefulness in the pure ductile metal form. In such form it has some theoretically remarkable properties as a structural material, being extremely resistant to corrosion and oxidation. In addition, it offers excellent strength at elevated temperatures up to the 1,093 deg. C. range. Apart from small quantities produced on a laboratory scale, however, ductile chromium metal still remains to be produced.

A step forward was recently taken in this direction, however, when Nuclear Metals Inc., produced what are thought to be the first successful extrusions of pure chromium tubing. Not only was tubing produced from powders but rods and flat stock were extruded from flakes.

Starting with laboratory grade chromium powder from Union Carbide Metals Company, who also produce chromium flakes, Nuclear Metals Inc. cold compacted the powder in a mild steel container which, following several processing steps including heating, was placed in a 1,000 ton press for extrusion into tubing. The resulting chromium tubing was very nearly perfect. Despite the fact that it had begun as a powder, it was almost as dense as the theoretical density of pure chromium metal.

During the first runs of this experiment a variety of tube sizes were made, including 1, 1.2 and 1.4 in. outer diameters, with 0.06, 0.07 and 0.10 in. wall thicknesses.

While the experimental apparatus can be considered a practical prototype production technique, further development of the product will, of course, be necessary before the long search for ductile chromium can be considered over. This search will go on because designers and engineers eagerly await a material with chromium's great oxidation and corrosion resistance coupled with good strength at high temperatures. For instance, chromium metal or chromium-base alloy in a ductile sheet might well provide a perfect skin for high-speed aircraft and missiles. Ductile chromium tubing could solve the problems arising from the necessity for containing hot exhaust and propulsion gases of rocket nozzles and jet tubes or it could serve as a fuel element cladding material for the nuclear scientist.

One of the goals of metallurgists in this direction is the production of even greater purity chromium, because purity and ductility seem to go together. In some quarters it is thought that greater purity may be achieved by the use of a scavenger element such as yttrium, one of the rare earths.

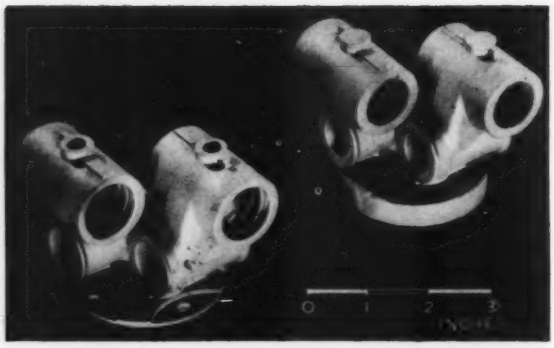


Illustration of how the investment casting process gives the designer great freedom with small complicated components.

Investment Casting Eliminates Fabrication

LABORIOUS AND EXTREMELY EXPENSIVE "knife and fork" methods and welding were the only alternative to the lost wax process for the production of this junction in heat resistant stainless steel from The British Investment Casters' Technical Association. Production as an investment casting completely eliminated fabrication, thus meeting the customer's specification for pressure-tightness. Although a certain amount of machining was needed as a result of the complex nature of the component, this was kept to a minimum because of the accuracy and surface finish obtained when using this technique. The designer thus achieved his aim to produce economically a component which is both sound and light in weight.

The investment casting process provides engineers with an exceptional degree of freedom in the design of small, high-quality, components in a wide range of ferrous and non-ferrous alloys.

Information on Asbestos

ASBESTOS, like other inorganic fibres, is primarily an industrial material and as such it finds uses in a multiplicity of products serving every branch of industry. In spite of the usefulness and versatility of this material, however, the technical information on asbestos is rather scattered and as a rule it is not easily available. A new publication called the Asbestos Bulletin containing accounts of mining activities, fibre properties and uses is intended to fill the gap in the literature currently available on this subject. Abstracts of British and foreign patents and literature will be included. The Bulletin is published by the Astex Publishing Co.

IN NEXT MONTH'S ISSUE . . .

Propulsion—Methods and Applications

A survey of systems under active development.

Irradiated Polythene

Outline of advantages, properties and applications.

A further look at leaf spring design

Recent progress in improving the efficiency of leaf spring design.

Materials for Rail Transport Units

How new materials are being put to use in the railways of the world.

Quartz in Engine Research

A SINGLE-CYLINDER overhead valve engine with a quartz-topped piston may give new information about the burning of air and fuel in high compression auto engines. General Motors Research Laboratories are using the engine as a new tool for combustion research, with a unique optical system by which for the first time natural colour motion pictures can be taken of the air-fuel "burn," exactly as it occurs in automotive engines in service.

Already it has made possible a series of high-speed colour photos of combustion at compression ratios as high as 10.7 to 1, offering researchers a more realistic view than they could get before, and combustion occurring under both road load and full throttle engine conditions.

Earlier "window" engines, L-head designs with quartz heads, never could be operated above 7-to-1 ratio, while today's valve-in-head engines range from 8-to-1 to 10.5-to-1. The basic difference between the new "window" engine and its predecessors is that high-speed photos are taken through the transparent top of its piston rather than through a quartz "window" in its head—from the bottom upwards instead of the top downwards.

Two technical problems which had to be overcome were firstly to find a satisfactory method of bonding quartz to the metal piston (this was solved by use of new adhesives) and secondly designing an engine to which the basic idea of a transparent piston top could be adapted. Such an engine had to be able to accommodate an elongated and heavy piston and an elongated cylinder. The piston crown is clear fused quartz with polished top and bottom surfaces for optical purposes.

Beneath the piston top is an angled mirror on which the combustion phenomena reflects and this image is photographed by a high-speed camera. Also necessary in the assembly is a transparent disc or collar at the top of the cylinder to admit external light into the combustion chamber.

Design Conference Proceedings

THE PROCEEDINGS of the Engineering Materials & Design Conference held in February this year are now available and include the following papers:

Reinforced Plastics 1960 by A. W. Thompson.
Research & Development of High-pressure Hydraulic Equipment by D. E. Turnbull and H. Stephens.
Preliminary Design of Rubber Components by A. N. Gent.
Design and Application of Investment Castings Produced by Centrifugal Methods by I. L. Gwynn.
Beryllium as a Structural Material by A. J. Martin.
Vacuum Melted Materials by H. C. Child.
Rotating Shaft Seals and the Engineering Designer by E. T. Jagger.
Plastics for High Temperatures by V. E. Yarsley.
The Case for Industrial Design by H. A. Nieboer.
Industrial Design in Engineering by R. M. Kay.
Standards in Design by R. K. Whitehead.
Safety in Design by B. Shackle.
Photoelasticity in Design by C. Snell.
Engineering Design in Britain, Germany and Russia by J. Shapiro.
Weldable High Strength Stainless Steels by J. I. Morley.
Some Developments in Fluid Power by D. Firth.
Magnesium Alloys by P. A. Fisher.
Powder Metallurgy by L. Harrison.
Cast Iron as an Engineering Material by H. Morrogh.
Pumps for the Processing Industries by J. O. S. MacDonald.

The proceedings are available from Heywood & Co., Ltd., Drury House, Russell Street, W.C.2. Price £2 2s.

FOR FURTHER INFORMATION:—

General Motors Corp., 1775 Broadway, New York 19, N.Y., U.S.A.
Reed Paper Group, 105 Piccadilly, London, W.1.
General Electric, Aircraft Accessory Turbine Dept., 950 Western Avenue, Lynn 3, Mass., U.S.A.
Three Point One Four Corp., 24, Woodworth Avenue, Yonkers, N.Y., U.S.A.
Astex Publishing Co., 22/23 North Street, Guildford.
The British Investment Casters' Technical Assoc., 5 East Bank Road, Sheffield 2.
Nuclear Metals Inc., Concord, Mass., U.S.A.
National Industrial Design Council, Ottawa, Canada.
Ministry of Aviation, Room 279, Shell Mex House, Strand, London, W.C.2.
Radiochemical Centre, Amersham, Bucks.
Wantage Research Laboratory, Grove Airfield, Wantage, Berks.

HIGH-SPEED ENGINEERING

THE recent announcement of an attempt by Donald Campbell on the world's land speed record is bound to rouse the interest of any engineer who retains a little of his boyhood memories of heroes like the late Sir Malcolm Campbell and the late John Cobb. Some people who have not taken the trouble to investigate very deeply are inclined to ask: "What is the point of spending a tremendous amount of money (in the case of the present Bluebird car probably well over £1,000,000) on a project which appears to have no practical significance?" As always with such arguments, there is a tendency to lose a sense of proportion, and while a million pounds may sound excessive expenditure, it is very small compared to the total annual expenditure on engineering research, if we include the efforts of the universities, private companies and Government establishments.

To give an example of another research venture, the Clarendon Laboratory, Oxford, have achieved what is believed to be the lowest temperature anywhere in the universe (of the order of 10^{-6} deg. K.), and whilst this is not an official record —those concerned with the work would be the last to claim it as such—nevertheless this work is the result of pure research into the properties of materials at very low temperature. It is not asked whether these experiments will immediately lead to a practical application, but it is believed that the ultimate benefits on a long-term basis will be considerable.

A characteristic of record breakers is that they are rarely content with having broken a record once, and even when there are no competitors it is not unusual for the same man to return year after year for a renewed attempt. It is not always appreciated that this persistence is not only the idiosyncrasy of a man possessed with a desire to beat all others, but is an essential part of a complicated research project. From the designer's point of view, the record-breaking vehicle, whether it be on land, sea or in the air, is an experimental testbed and nothing can be more frustrating than a too easy attainment of the particular record being attacked. It is mainly by failure that the designer learns to progress, and to call off the project immediately a given figure or speed is reached means a loss of much engineering data.

The new Bluebird car is a major feat of British engineering and the glamour surrounding an attempt at the land speed record should not be allowed to overshadow this. Unlike many research projects involving considerably greater expenditure, it is already possible to see some benefits from the research which has gone into the design of this car and its components. For instance, the load on the gears is expected to reach a figure of over 4,000 p.s.i. and a special lubricant has had to be developed by the British Petroleum Co. for this application. The existence of such a lubricant may well open up possibilities for increased loadings in many branches of engineering. Preliminary tests on the disc brakes which have to contend with some 40 million ft. lb. of energy in 60 sec. have shown that the discs themselves may run at temperatures over 1,000 deg. C., and Ferodo Ltd. have had to develop special friction pads to cope with this extremely arduous condition. Probably the most interesting factor in the new car is the use of an aluminium honeycomb-cell type structure for the main frame and this is believed to be the largest structure that has ever been made from this material. The fact that the designers were first introduced to the material by reading of it in ENGINEERING MATERIALS AND DESIGN gives us an added interest in its successful application, and we may soon see its use in the automobile industry and in other applications where a very rigid lightweight frame is required.

To Donald Campbell and his team we send our best wishes for a successful attack and to Norris Bros., the designers, and the 69 firms who have so nobly responded by giving cash and kind our congratulations on making a contribution to an endeavour which, if successful, will result in tremendous publicity for British engineering.

The Editor

RUBBER FOR HIGH TEMPERATURE SERVICE

by D. A. SMITH, M.Sc., A.R.I.C., A.I.R.T., A.N.C.R.T.*

The demand for rubbers to withstand higher temperatures is growing and this article outlines the properties and limitations of some of the materials now available for high temperature applications

THE use of rubbers in high-temperature applications was formerly restricted by the relatively poor thermal stability of natural rubber compounds. Increasing demands by design engineers in fields such as aircraft and rocket research has stimulated the development of special-purpose synthetic rubbers which are capable of retaining their properties at temperatures up to about 260 deg. C. for considerable periods, and it is possible that in a few years this ceiling temperature may be raised still further. While the prospect of "red-hot" rubbers is of great interest, the designer must also be aware of certain limitations in the use of high-temperature rubbers determined by their rather unconventional chemical structures; for example, in general, the processing ease and mechanical properties of a rubber seem to be almost an inverse function of its high-temperature performance and so some skill and experience are necessary in making the compromise selection of a rubber for severe mechanical service conditions at an intermediate level of service temperature.

Nature and Constitution

The rubber components employed by engineers are dependent for their service properties on three principal variables:

1. The nature of the base elastomer, that is the "raw" natural or synthetic rubber, this being the main determinant of high-temperature stability.

2. The compounding of the chosen elastomer, that is the choice of suitable ancillary chemicals such as vulcanising agent, accelerator, filler, plasticiser, antioxidant, etc., which are added to develop the full mechanical properties of the rubber or specifically to retard its deterioration in particular circumstances. Compounding is less important than the choice of a sufficiently heat-stable base elastomer: however, skilful compounding may enable the use of a moderately-heat-resistant elastomer above its normal range of service temperature in order to meet particularly severe mechanical service conditions.

3. Processing, including vulcanisation. Although an important variable in specific cases, variations in processing are usually limited by the shape of the rubber article and by its specification for mechanical properties rather than by considerations bearing on the retention of those properties during service.

Properties of Rubbers

It is conventional to define rubber properties in terms of physical and chemical properties, although from the fundamental viewpoint the distinction may often seem rather arbitrary.

Physical properties include the results of tensometric measurements such as ultimate tensile strength and breaking elongation. While these are hardly ever of interest to the design engineer as such, they are nevertheless most sensitive to changes occurring during high-temperature exposure and so may be used in characterising rates of deterioration. Hardness or compression modulus is of greater intrinsic interest, as are measurements of rebound resilience, "set" in tension or in compression, stress relaxation and creep. Specific service conditions may call for measurement of resistance to abrasion and tearing, dynamic failure, for example, by flexing, and other properties such as electrical insulation behaviour.

Chemical properties include resistance to oxidation, ozone attack, swelling and degradation by oils and solvents and sometimes by exposure to other deleterious chemicals such as acids and alkalis and even water for some rubbers!

Effects of Elevated Temperatures

In considering the effects of temperature, it is necessary to distinguish clearly between two measurements:

1. The relationship between "property" and temperature.

2. The maintenance of property with time of exposure at the elevated temperature.

The first type of measurement is the more difficult in that conventional equipment for British Standard[1] and other physical tests is not well adapted for operation at high temperatures without extensive modification and, in the past, the majority of investigators have contented themselves with measuring the properties at *room* temperature of rubbers which have been aged under various simulated service conditions. The data given in Fig. 1 were obtained

* *National College of Rubber Technology.*

in this way by the author some years ago in the investigation of rubbers for service in dry air at 120 deg. C. and hitherto unpublished. The compounds used are appended and are fairly representative of current practice in the treatment of the three polymers, the tests being typical of those used in any rubber service laboratory concerned with evaluating compounds for engineering applications.

While such measurements are adequate for many purposes, it has been recognised in recent years that the more useful design constants require measurement of rubber properties at the *service* temperature, and ingenious modifications of standard testing equipment have been made by laboratories in the U.S.A., in Germany and latterly in the U.K. In fact, one of the earliest papers reporting both the results of measurements at high temperatures and the effects of continued exposure at these temperatures was published in Germany by Peters.[2] Later papers by Konkle, McIntyre and Fenner[3] extend measurements of tensile strength and ultimate elongation up to nearly 260 deg. C. with ageing periods at 70, 130, 150 and 200 deg. C. for up to sixty days at the lower three temperatures and fourteen days at the highest temperature, the work covering ten different elastomer compounds. Smith, of the Firestone Tyre & Rubber Co., has presented a very comprehensive report covering nineteen compounds at temperatures up to 287 deg. C. and has reported not only tensile properties but also Shore A hardness, rebound resilience, tear strength and permeability to air.[4] A comprehensive evaluation programme is in progress by the Research Association of British Rubber Manufacturers, but no publications have appeared as yet other than reports of a confidential nature.

It will be clear from the foregoing remarks that the accurate evaluation of the physical properties of rubbers at elevated temperatures is in its infancy and must be regarded still as a research problem in the design of suitable test equipment rather than as the basis for a possible new clause in a material specification. Progress has been made in tensometry, but the measurement of other important properties such as resistance to abrasion still offers difficulty even at room temperature. Nevertheless, despite these reservations, enough data exist to enable us to draw broad conclusions about the high-temperature performance of a wide range of rubbers which may prove of value to design engineers despite its rather qualitative nature.

The requirement that a rubber should retain its mechanical properties at high temperatures is not in itself unreasonable. Even natural rubber, which is not usually regarded as showing outstanding resistance to heat, will retain high strength and reasonable flexibility provided that exposure is in the absence of air. Progressive hardening and increase in modulus will occur at first on account of continuation of the vulcanisation reactions leading to a denser molecular network, but later the network may break down to give a softer "reverted" rubber. In the presence of oxygen, the state of affairs is very different, since "scission reactions" take place leading to a reduction in the density of the network on which the rubbery properties depend. While this picture may be grossly simplified from the chemical stand point, it serves to demonstrate the nature of the two competitive reactions, stiffening and softening, and to give some hint as to their origin. The importance of oxidative processes in rubber ageing at elevated temperatures makes it of the greatest importance to define clearly the conditions of service and underlines a point which many designers have learned to their cost, that circulating air may prove a worse enemy of rubber than hot oil, particularly if the rubber has been chosen carefully with due regard to its swelling characteristics and proper compounding. There are many rubbers which will remain serviceable to much higher temperatures than would be suggested by air oven ageing data, provided that they are serviceable immersed in an oil which is either resistant to oxidation or is oxidised in preference to the rubber.

TEMPERATURE BANDS—It has been suggested by the author[5] that the rubber service temperature scale be divided into a number of arbitrary bands, each of which marks the limit of high-temperature serviceability of a rubber or range of rubbers. Special compounding techniques, however, may be used to move a polymer up into the next higher band or (rarely) even two bands higher. The bands suggested are:

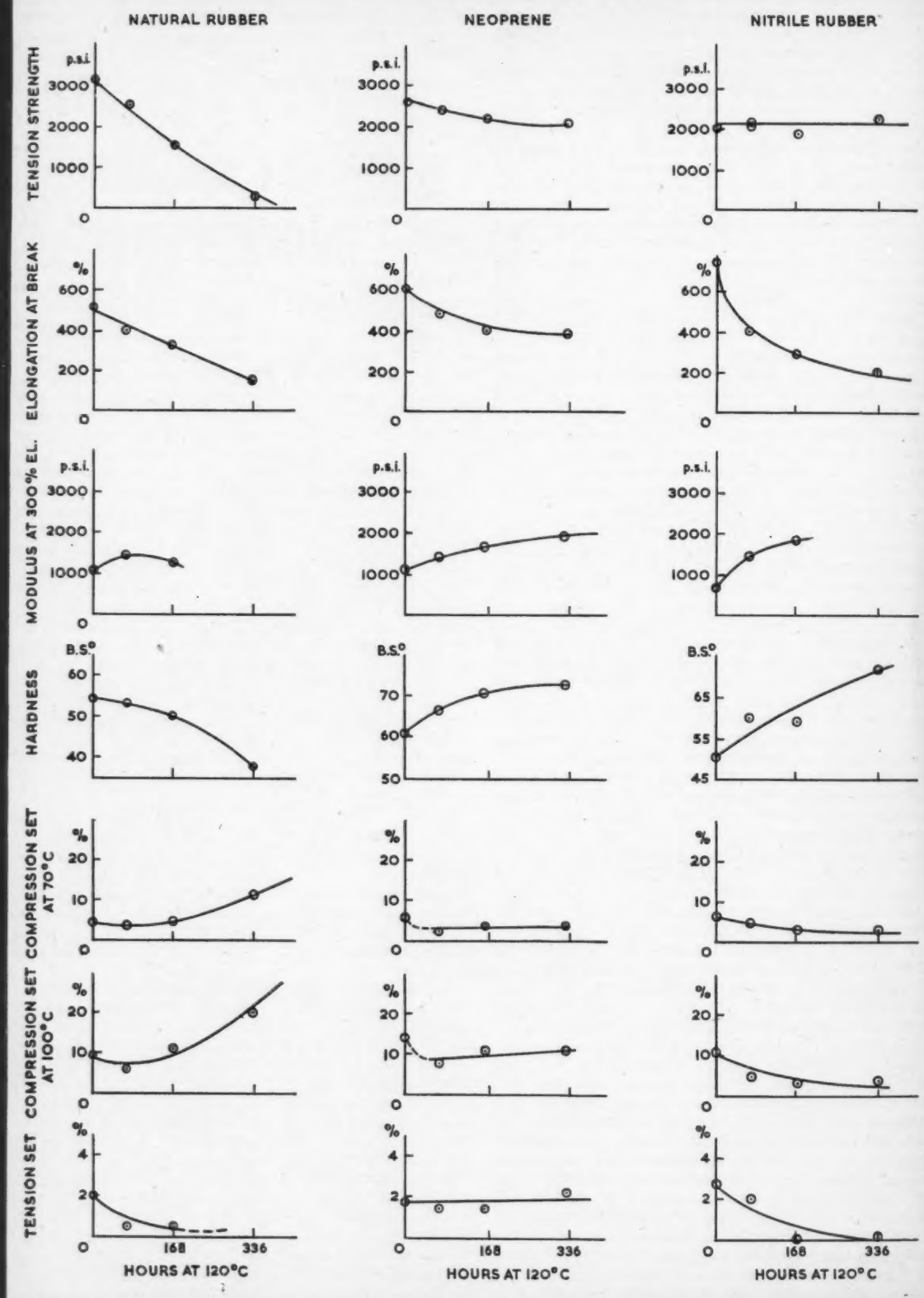
Up to 70 deg. C.	Band I
70-100 deg. C.	„ II
100-130 deg. C.	„ III
130-160 deg. C.	„ IV
160-200 deg. C.	„ V
200-250 deg. C.	„ VI
Above 250 deg. C.	„ VII

The determination of "service life" may provide some difficulty. It is frequently assessed by such methods as plotting the logarithm of the exposure time in which the ultimate elongation drops to 100 per cent (i.e., twice the original length) against the temperature of ageing in a circulating air oven. For a number of rubbers such a plot is approximately linear and may be used to predict service life.[6] The temperature characterising the limit of serviceability may be fixed in many ways and it has been suggested to be that at which the rubber is exposed continuously in circulating air so as to cause the ultimate elongation to fall to 100 per cent in 100 hr. Obviously, for many purposes, this criterion will prove too stringent, for there are applications where as great an elongation as 100 per cent is not a condition of service. It has already been indicated that tensile properties are particularly sensitive to structural changes brought about by heating. Some rubbers, such as butyl, "revert" on heat ageing, becoming soft and sticky with high (irreversible) elongation. For these, assessment of deterioration may be by change of hardness value or by a rather more fundamental test than those mentioned hitherto, by measurement of stress relaxation. In summary, then, there is no single property which may be used as a yardstick of high-temperature performance. Rather, it is necessary to examine a range of properties before selecting suitable criteria.

Band I. All the true, i.e., vulcanisable, rubbers behave satisfactorily at temperatures up to 70 deg. C. Some rubbery thermoplastics such as plasticised p.v.c. are not satisfactory even at this temperature on account of excessive softening and creep.

Band II. Natural rubber (N.R.) and styrene-butadiene rubber (S.B.R.) are greatly affected by continuous exposure at temperatures in excess of 70 deg. C. unless specially compounded.[7] Furthermore, even the unaged compounds show a rapid reduction of tensile strength with increase in temperature, although it is necessary to bear in mind that the initial strengths of N.R. and S.B.R. black stocks are much in excess of the strengths of many of the special-purpose synthetics.

Band III. The chloroprene rubbers (neoprenes, C.R.) show similar loss of tensile strength with increase of temperature, but better retention of elongation and strength on prolonged heating. Suitably compounded acrylonitrile-butadiene rubbers (nitrile rubbers, N.B.R.) show excellent retention of strength, but continued cross-linking leads to rapid loss of elongation and increase in hardness, although this does not show up well in Smith's paper,[4] possibly because his chosen compound would not appear to be accelerated for optimum heat-ageing characteristics. Both C.R. and N.R. show good tear resistance in this temperature band and it is a serious defect of the majority of current synthetic rubbers that their tear resistance at elevated temperatures is very poor indeed. Quoting again from Smith,[4] the tear strength of a N.R. compound at room temperature 23 deg. C. was high at 864 lb./in. which fell to 311 lb./in. when the temperature of test was increased to 150 deg. C., whereas the corresponding tear strength values


NATURAL RUBBER
NEOPRENE
NITRILE RUBBER
TENSION STRENGTH
p.s.i.
3000
2000
1000
0
ELONGATION AT BREAK
%
600
400
200
0
MODULUS AT 300% EL.
p.s.i.
3000
2000
1000
0
HARDNESS
B.S.°
60
50
40
70
65
55
45
COMPRESSION SET AT 70°C
%
20
10
0
COMPRESSION SET AT 100°C
%
20
10
0
TENSION SET
%
4
2
0
168
336
HOURS AT 120°C

FORMULATIONS
(parts by weight)

Natural Rubber RSS 1	100.0
Zinc Oxide	5.0
Stearic Acid	1.0
FEF Black (Philblack A)	30.0
Phenyl- β-naphthylamine (P.B.N.)	1.5
Tetramethyl thiuram disulphide	3.0
Mercaptobenzthiazole	0.5
Press cures at 310°F. for $\frac{1}{16}$ in. sheets	30 mins.

Medium Nitrile Rubber (Hycar 1042)	100.0
Zinc Oxide	5.0
Stearic Acid	1.0
Philblack A	25.0
P33 Black	40.0
P.B.N.	2.0
25° Coumarone-Indene Resin	10.0
Hexaplas PPL	10.0
Tetramethyl thiuram disulphide	4.0
Press cures at 310°F. for $\frac{1}{16}$ in. sheets	25 mins.

Neoprene WRT	100.0
Zinc Oxide	10.0
Stearic Acid	0.5
Philblack A	15.0
FT Black (P33)	25.0
P.B.N.	2.5
Lt. Magnesium Oxide	4.0
Ethylene thiourea	1.5
Benzthiazyl disulphide	1.5
Press cures at 310°F. for $\frac{1}{16}$ in. sheets	45 mins.

METHODS OF TEST

Tests were carried out according to B.S. 903 : 1950 on sheets moulded between stainless steel plates 24 hours after mixing. A further period of 24 hours was allowed after moulding and before cutting out the test pieces. Ageing was carried out in T and M circulating air ovens using a separate oven for each compound in order to prevent migration of volatiles. Unless otherwise stated, tests were carried out at ambient temperature (65°F) on test pieces allowed to stand 24-hours after removal from the oven. Compression set tests were performed under constant (30) deflection conditions using 3 test pieces. Results quoted are for 10 min. recovery at the oven temperature plus 10 min. immersion in cold water. [Although the same deflection was used throughout for comparison purposes, the results will only comply with B.S. procedure for rubbers whose hardness values lie between 46 and 65 B.S.]

for a much publicised high-temperature fluoro-rubber produced in the U.S.A. were 179 lb./in. at room temperature and 23 lb./in. at 150 deg. C. The tear strength at one of the recommended moulding temperatures, 200 deg. C., was 4 lb./in., hardly sufficient to strip it from the mould without damage. For short-term exposure, even at quite high temperatures, where mechanical properties are at a premium, the intelligent designer may often use natural rubber, although it is "against the book". Nevertheless, experience is necessary in order to assess the probable service life of the component under such conditions. It is in cases like this that simulated service tests are the only way to a satisfactory answer.

Also in Band III, the polyurethane rubbers are a little difficult to group usefully, since there exists a wide variety of both the polyester and polyether[8] types. High-temperature characteristics may differ markedly one from another particularly when different vulcanising systems are employed. In general, the initial high tensile strength falls very sharply with increasing temperature (up to 50 per cent. deterioration from room temperature to 90 deg. C.) although ageing periods at temperatures up to 150-180 deg. C. do not have a great effect on the retention of tensile properties at least in the case of the chemically saturated grades. Polyurethanes are readily degraded hydrolytically; e.g., by exposure to acids, alkalis or steam.[9]

A most important rubber for service in this band is butyl,[10] although intelligent compounding is of the utmost importance in combating reversion softening. Use of "high unsaturation" grades of polymer cured tightly with high accelerator loadings or with oxidising agents instead of sulphur often give good performance. Further improvement may be effected by using halogen-activated dimethylol phenolic resins as alternative curatives, and for some purposes (e.g., tyre curing bags) satisfactory behaviour has been reported at temperatures as high as 170 deg. C. Sulphur-cured butyl rubbers show good tear strength up to quite high temperatures, values reported being about one-half of those of representative natural rubber/black stocks measured at the same temperatures. The retention of properties on prolonged exposure at elevated temperatures is much better for butyl and it will be interesting to see if the new Montecatini[11] rubber C23, a copolymer of ethylene and propylene which when vulcanised is chemically saturated like butyl and therefore resistant to oxidation, will combine the high level of properties of N.R. with the better retention behaviour of butyl.

Band IV. For continuous service at temperatures up to 160 deg. C., where little change in physical properties during prolonged exposure is a prerequisite, special elastomers have been developed which include chlorosulphonated polyethylene (Hypalon), polyacrylic rubbers (Hycar 4021, Acrylon EA-5) and a series of carboxylic polymers, many of which are still under development.

Hypalon[12] is resistant to ozone and chemicals and is flame-resistant. It shows moderate swelling in aliphatic oils, but is not resistant to aromatics. The polyacrylics[13] are true oil-resistant rubbers and have found application in seals for extreme pressure lubricants which are used in hot-running transmission units for heavy motor vehicles.[14] They are not resistant to water and generally show rather poor low-temperature flexibility, properties such as resilience also being much lower at room temperature than at higher temperatures (a characteristic also of butyl rubber). Blends of polymers are often recommended for service in this region: butyl/Hypalon and N.B.R./phenolic resin blends are popular where specifications are not too severe with respect to hardness changes on exposure. Where this factor is of importance other blends may be examined: the author has recently evaluated blends of polyacrylic rubber, N.B.R. and phenolic resin, and the results given in Fig. 3 show that by use of a hot-air post-cure it is possible to meet this condition also. It would appear that these blends

may show poor flex life, possibly on account of limited compatibility between the acrylic rubber and the resin. The addition of N.B.R. and phenolic resin improves processing and allows the production of harder rubbers without recourse to high filler loadings.[15]

Carboxylic rubbers[16] such as Hycar 1072 are employed where combinations of oil resistance with good performance at both high and low temperatures is important, such as, for example, in certain aircraft applications. Recent developments in this field have been the introduction of special curing systems involving metal oxide/epoxide resin combinations and, using these, carboxylic rubbers have been prepared which have tensile strengths as high as 1,400 p.s.i. at 200 deg. C. and which show good retention of properties at somewhat lower exposure temperatures.[17]

Band V. At temperatures approaching 200 deg. C. it is necessary to employ rubbers of rather unconventional chemical structure. The vinyl silicones[18] are useful in that they may be processed readily in conventional rubber equipment, mouldings, for example, showing shrinkages not much greater than those observed with many organic synthetic rubbers. While they are usually vulcanised with organic peroxides such as dibenzoyl dicumyl peroxide, sulphur vulcanisation is sometimes possible, and this enables these rubbers to be co-vulcanised with less resistant organic rubbers for particular applications where the relatively low level of physical properties of silicone rubbers is objectionable. Such blends do not seem to have gained wide acceptance, however, since some of them seem to combine the disadvantages of each constituent rather than their desirable properties.

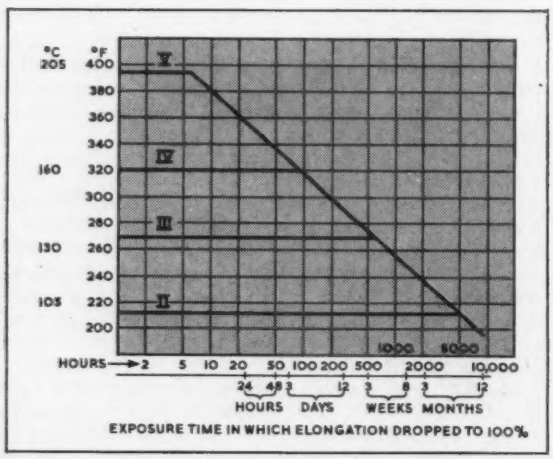


Fig. 2. Heat-ageing characteristics of Hypalon. (Circulating air oven, A.S.T.M. D 573.)

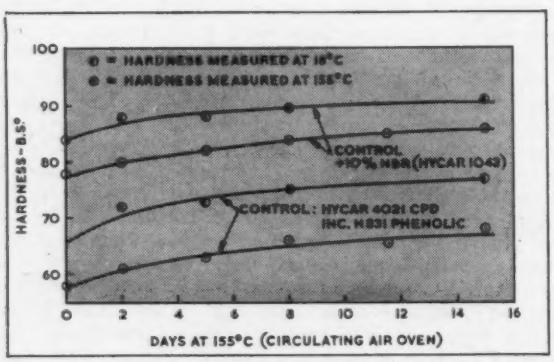


Fig. 3. Effect of ageing on hardness of polymer blends in Band IV. (Blends of acrylic rubber, N.B.R. and phenolic resin.)

Where oil or fuel resistance is required, fluoroester rubbers such as Fluororubber-1F4 (formerly Poly-FBA)[19] give useful performance, and acrylics such as Acrylon-BA 12 have been favourably reported.[3]

Band VI. Whereas it is sometimes possible to compound conventional organic elastomers for service in Band V with considerable improvement in material cost and frequently in processing ease also, continuous service at temperatures above 200 deg. C. can only be met by the use of methyl silicone rubbers or by the more exotic fluororubbers.[20]

Methyl silicones require great care in processing in order to avoid contamination with organic materials, they are generally more difficult to process than their vinyl counterparts and show high shrinkage during the two-stage mould/oven cure which is usually required to develop the rubber's full properties.[21] Where such materials as these are specified, the widest possible tolerances should be given by the designer, or the rubber manufacturer may find great difficulty in manufacture of intricate components. Fortunately, recent advances have made available easier processing (vinyl modified) grades for use in this region.

Oil and fuel resistance in this temperature region have hitherto required the use of fluoro polymers such as Kel-F elastomers 3700 and 5500,[22] Viton A or A-HV[23] or the fluorinated silicone elastomers LS53[24] and LS63. None of these is very easy to process, all of them are expensive (*ca.* £5/lb.) and little technical know-how exists in the U.K. which could assist in large-scale factory production. However, many firms have experimented in the laboratory and even produced small quantities of special components, principally for aircraft applications.

A recent development which may give us an oil-resistant Band VI rubber at a fraction of the present cost is the marketing by the silicone products department of the U.S. General Electric Co. of a nitrile-silicone polymer which can be processed on ordinary equipment.[25] This does not appear to be available in this country at the time of writing, but its arrival is anticipated with the greatest interest.

Band VII. At 260 deg. C. and above none of the established rubbers performs adequately. In an investigation of seal rubbers in hydraulic fluids, the U.S. Government reported last year[26] that two commercial elastomers performed satisfactorily in continuous service at 200 deg. C., but neither would remain serviceable when the test temperature was raised to 290 deg. C. Precautions in carrying out fuel immersion tests at such high temperatures have been reviewed in a recent report.[27]

In an advanced stage of development there exist several fluororubbers designed for use in the Band VII region. Fluorocarbon elastomer 214 has been reported to resist air, hydrocarbon fuels, motor oil and diesel oils for extended periods at 260 deg. C. and for limited short periods at 315 deg. C.[28]: the perfluoropolyphenyls, while poor in physical properties, show potential thermal stability up to over 480 deg. C.[29]

Future Developments

Polymer science and technology is a rapidly expanding subject and the present pace of development is unlikely to slacken in the immediate future, particularly in view of current interest in rocket-powered transport. Higher temperature rubbers will be developed along two main lines:

1. Extension on the current programme of highly fluorinated compounds of a "semi-organic" character.

2. Development of new inorganic polymers based on silicon, phosphorus, boron, tin, aluminium, titanium and other metals.[30]

It has been pointed out by Andrianov and others that the ceramic materials such as corundum, whose refractory

properties we prize so highly, are similar in structure to cross-linked inorganic polymers, and it may be only a matter of time before we are using the high stability of the oxygen-metal bond in much the same way to prepare rubbery materials. Much work remains to be done, but the prospect of "red-hot" rubbers may well become reality in the immediate future.

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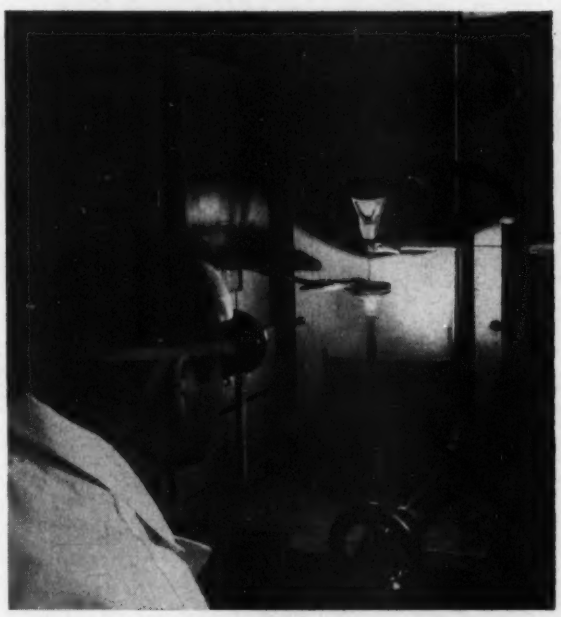
SINGLE CRYSTAL FERRITE RESEARCH

SINGLE ferrite crystals grown by the flame fusion process generally possess two short-comings: gross crystal defects due to extreme stresses set up by thermal gradients, and an appreciable content of ferrous iron. The former defect results in cracks and bubbles which obscure the intrinsic properties of the material, while the ferrous iron leads to increased electrical conductivity.

In a research programme undertaken at the International Telephone & Telegraph Laboratories, Nutley, New Jersey, sponsored by Air Force Cambridge Research Centre, a solution to these problems has been sought by improved crystal-growing techniques, based in part upon the flame fusion process.

To reduce the temperature gradients it was decided to enclose the growing crystal within a radio frequency induction heating coil. This technique is effective only if electrical losses can be induced in the crystal, a condition which is met by ferrites at elevated temperatures. At about 5-6 Mc/s induced internal heat losses were produced which provided a means of maintaining the growing crystal at temperatures just below its melting point and annealing it in a controlled manner upon completion of growth. As a result, it became possible to grow ferrites $\frac{1}{4}$ in. or more in diameter and several inches long without gross defects.

The second major problem to be dealt with was excess ferrous iron, which may also be expressed as an oxygen deficiency in the crystal lattice. The elimination of the flame made possible the control of the environment of crystal growth so that atmospheres of pure oxygen can be used. In the apparatus shown in the photograph material in the form of powdered ferrite drops from a feeding mechanism on to a "seed" crystal whose upper end is maintained as a molten pool at about 1,600-1,800 deg. C. by a radio-frequency induction heating coil. As the powder drops into the melt, it is quickly melted, and the stirring action of the radio-frequency field assists in achieving chemical homogeneity. The feed rate, heat input and pulling rate of the crystal are regulated so as to maintain a molten pool commensurate with crystal diameter at all times. As the crystal grows, it is lowered into the field of a second coil,



Apparatus for feeding powdered ferrite on to seed crystal.

somewhat more loosely coupled than the melting coil. This work coil serves to maintain the grown portion of the crystal at an annealing temperature of about 1,200 deg. C., in order to avoid cracking due to temperature gradients. The region in which growth and annealing take place is enclosed in a chamber in which the atmosphere can be controlled. At present, pure oxygen at atmospheric pressure is being used.

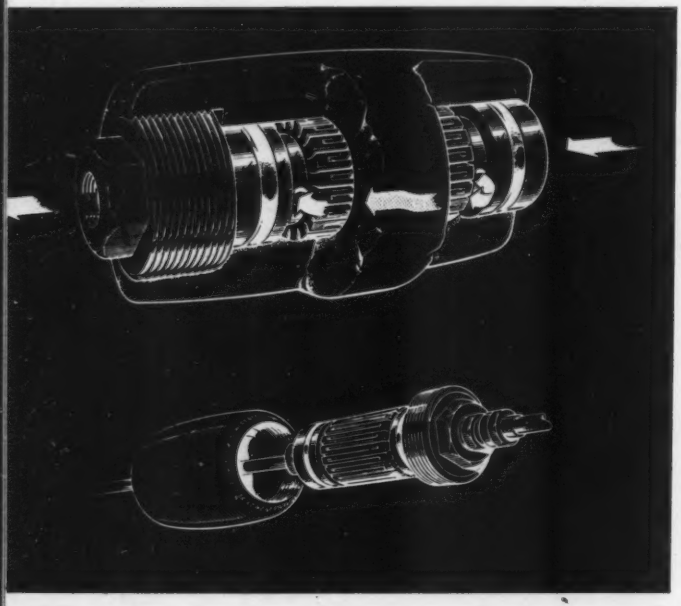
This work has resulted in the ability to grow ferrite single crystals of controlled, uniform composition with very few of the defects formerly encountered.

NEW IDEAS IN DESIGN

Outstanding products in current manufacture

An Adjustable Filter for Fluids and Gases

A NEW filter by I.V. Pressure Controllers Ltd., exhibited at the recent International Compressed Air and Hydraulics Exhibition, is claimed to be the first to provide means whereby the size of particles retained is adjustable. No gauze, paper or other permeable materials are employed in its construction, the operational principle being quite different from what is normally encountered.



The part sectioned and exploded views of the filter illustrate the working principle. The filter element has been designed in the form of a conical male plug arranged to fit within a similarly tapered female housing. Longitudinal grooves extend along part of the length of the element, but only half of these grooves are accessible to the fluid as it enters the filter, and to escape it must pass, via the filtration gap, into the adjacent groove to that which it occupies. The filtered particles are retained in the grooves.

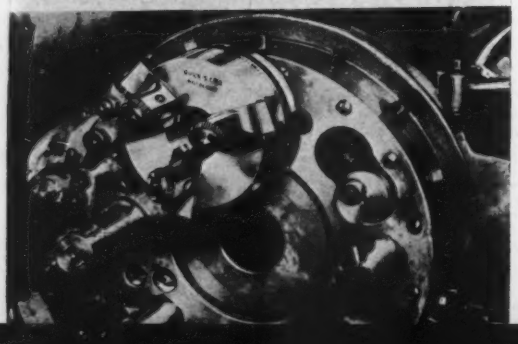
An important merit claimed for this arrangement is that it enables the filter to function equally well regardless of the direction of flow. It could be installed either way round.

The filter barrel bore is substantially a faithful reproduction of the external shape of the filter element. Element and housing are secured together by the particle size adjusting screw. To adjust the filtration gap, the element is held stationary by means of a spanner on the hexagon at its screwed end. The housing is then rotated by a spanner applied to flats provided for the purpose.

The choice of filtration range can be from 0 to 5 microns, adjustment being infinitely variable. Standard models cover the ranges of 6 and 11 microns and there are three models for each pipe size. The ¼-in. model accommodates ¼-in. o.d. inlet and outlet pipes and the three variants of this model cater for ranges of 0 to 5 microns; 5 to 15 microns; 15 to 25 microns. Seven pipes sizes are catered for, ranging from ¼ in. to 1 in. o.d. in increments of ¼ in. Working pressures are currently of the order of 4,500 p.s.i., a further range suitable for pressures up to 6,000 p.s.i. being under development.

An important advantage of the filter would appear to be the ease with which it can be cleaned without breaking the pipeline. It is only necessary to unscrew the housing and slide it a short distance along the adjacent pipeline.

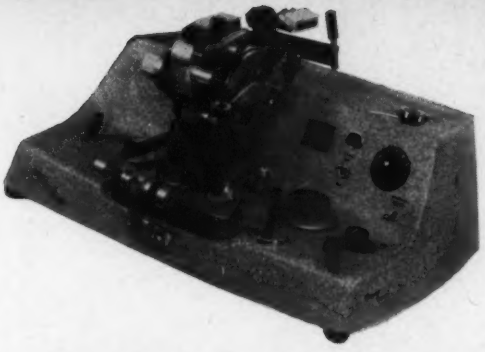
An Ingenious Knurling Cutter



THE production of clean, sharp knurls on turned components relies on merely pressing into the rotating part a serrated wheel which, under the considerable force usually necessary, deforms the surface. For this to be successful it is essential that the component be very rigidly held and that the knurling tool be sharp. Very often an otherwise well-turned component is spoiled by the quality of the knurling and the distortion arising from its production. Large burrs are frequently caused, which, when they are not at the end of the component, are sometimes difficult to remove.

A range of knurling tools introduced by Miller, of Innsbruck, would appear to have solved this problem. These tools actually mill the knurling and produce chips while doing so. Although not powered by anything other than the workpiece itself, the knurling rollers are arranged at such an angle to the work and the cutting teeth positioned in such a way that actual cutting takes place. Various types of Miller knurling tools are available for centre lathe, capstan and turret lathes. The cutter wheels would appear to be of a rather higher standard than those seen on conventional knurls, being made of high-speed steel with ground teeth. A large range of both straight and cross knurl cutters is available.

High-speed Toroid Winding Machine



THE new Gorman model 600 high-speed toroid winding machine has now been introduced into the U.K. by Aveley Electric Ltd.

Designed and engineered to operate as a production line toroid winder or a prototype model maker, the machine is claimed to be unique and incorporates many new features which allow for the rapid insertion and removal of cores. Cores may be rotated as desired, either through 360 degrees, or segmental over any angle up to 360 degrees, or may be adjusted for a fixed increment of progression on a constant angle of rotation.

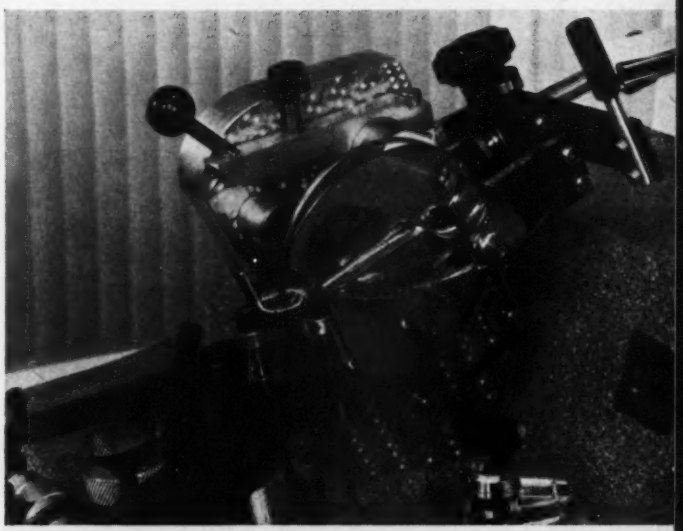
For bank winding the machine can be set for any sector and rate of progression.

A transistorised electronic counter and Sodeco register is fitted to ensure accurate counting of turns.

In order to maintain a constant, even drive the core is rotated by means of three co-ordinated driving rollers, which can be continually centred by a single control lever. The speed of rotation is controlled by adjusting a Vernier.

The machine is provided with overriding hand, foot or automatic control, and to ensure stopping at high speeds without wire breakage a dynamic braking system is employed. Provision is also made for the connection of a predetermined counter, which will stop the machine automatically after the required turns have been made.

The Gorman model 600 has a variable winding speed between 0 and 1,200 turns per minute and will utilise wire between 27 s.w.g. and 48 s.w.g. The core size range allows for a minimum finished i.d. of 0·055 in. with respect to height, and a maximum o.d. of 2 in. with a maximum height of 1 in. The weight of the machine is 55 lb.

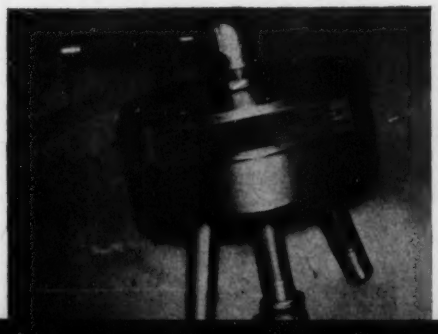


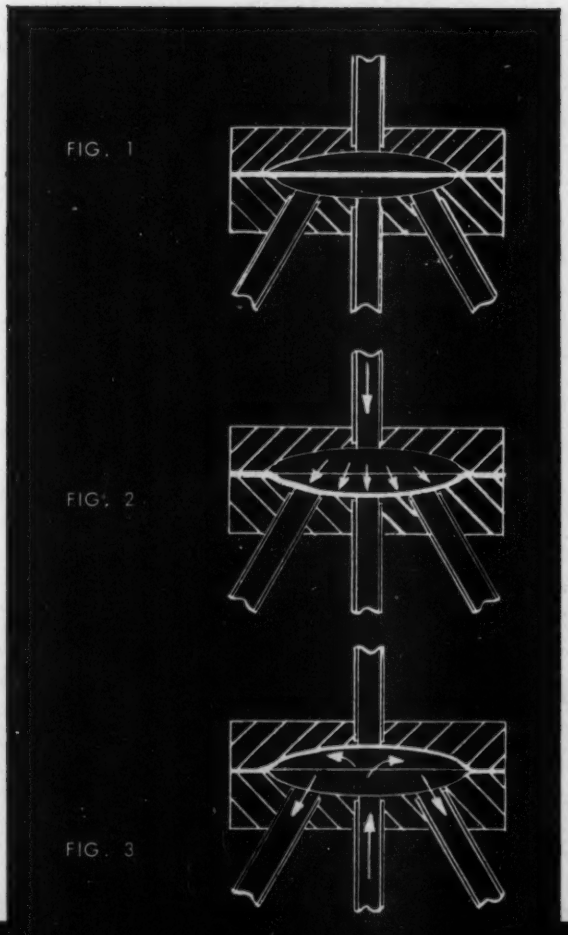
Differential Pressure Diaphragm Control Manifold Valve

A NEW type of valve introduced by Frankel Engineering Laboratories Inc., of Reading, Pa., U.S.A., has only one moving part and operates on a differential pressure principle. It has been designed to meet the needs of automation.

The top portion of the valve is known as the control side and the bottom portion of the valve as the working side. The control side of the valve may utilise such fluids as air, water, steam, hydraulic fluid or inert gas. The working side can be used with water, steam, water-soluble oils, lubricating oils, hydraulic fluids and gas. The working side of the valve may be used to divide flow, with one inlet emptying into a common outlet.

Fig. 1 shows a cross-section of a typical valve with no pressure on either the control or working side. Fig. 2 shows the effect of pressure on the control side, the diaphragm being displaced to seal off inlet and outlet ports on the working side. Fig. 3 shows the valve when the control side pressure takes over. Flow is divided into one or more outlets.





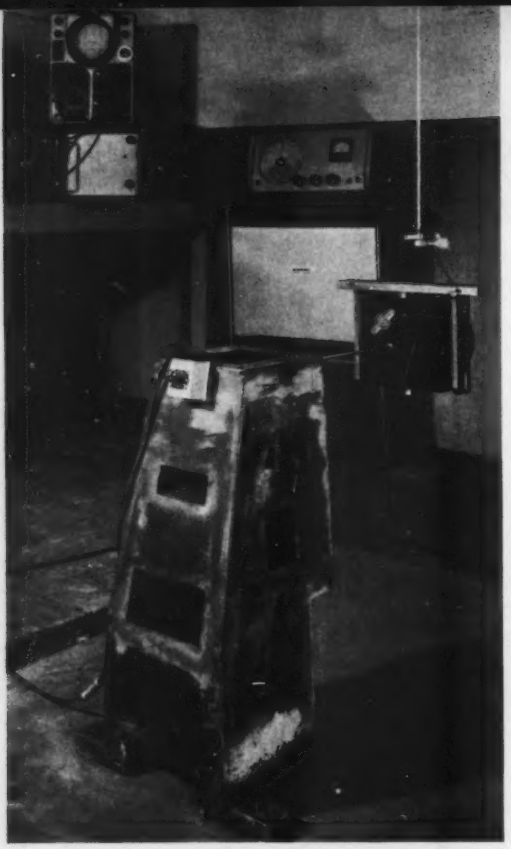


Fig. 1. Model structure undergoing extensive development tests at Newall Engineering.

INTERNATIONAL MACHINE TOOL EXHIBITION 1960

by R. W. NEW, A.M.I.Mech.E.

OVER the past ten years increasing use has been made of results from research into the performance of machine tools, and many examples of machines embodying these results will be exhibited by leading British manufacturers. Following also from these researches, the new techniques which have been used for carrying out experiments are rapidly becoming adopted as a standard method of development by the manufacturers.

Amongst the more powerful and searching techniques used by research engineers, that of vibration testing is now highly efficient and has been adopted by progressive design teams in their constant endeavours to seek perfection. This aspect of research has shown in a very convincing manner how dynamic force tests on a machine at its resonance frequencies can provide an exacting method of studying the response characteristics of machine tool structures.

Older established methods of static loading were never so searching into the distortion of a structure owing to the difficulties encountered by the very large number of measuring elements required, the choice of a reference base and so on. However, the use of vibration pick-ups in conjunction with dynamic force generators has altered the picture almost completely. A vast number of readings can be obtained covering whole areas of structural walls, ribs, etc., which can be correlated by elementary graphical means to give the designer a complete picture of machine distortion under load.

Such dynamic tests are now supplemented by tests on scale models and have permitted designers to develop optimised machine tool structures possessing characteristics which may be several hundred per cent better than yesterday's designs in actual performance. Thus a new breed of machine tools is rapidly becoming apparent, for it is realised that the structure is, in fact, the backbone of a precise metal skeleton. The greater the rigidity of this backbone, the less distortion of all the structural elements. This ensures freedom from the chatter zones, reduced distortion of bearings and gear trains, with a consequent drop in heat and noise generation, and finally a greater geometrical accuracy and finer finish of the workpiece for no increase in cost.

Also stemming directly from research are the many improvements in positional accuracy, measurement and precision corrective devices, many examples of which will be shown at the exhibition.

Amongst well-known British manufacturers who use this forward-thinking approach to design are such firms as Newall Engineering, David Brown, Gisholt-Lang, H. W. Kearns, Denham Engineering, Midgley & Sutcliffe, etc., showing that size of firm and type of machine are not limitations to enterprise in modern development.

Fig. 1 shows a model of a column structure undergoing

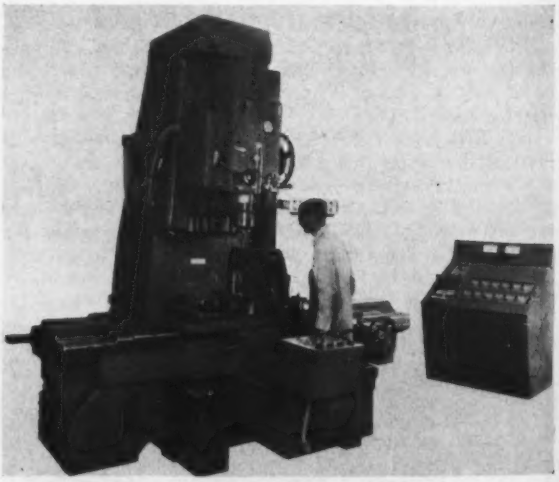


Fig. 2. Newall spacematic 2657 jig-borer fitted with automatic co-ordinate setting system.

extensive tests in one of the several development bays at the Newall Engineering Co. The particular model shown is of fabricated steel and is one of a series which have been systematically studied. Plastic models have also been extensively used, and many unique structures have been developed and successfully proved under exacting production conditions in their own and customers' works.

Jig Boring Machines

Newall Engineering will be displaying five jig-borers, including three completely new designs, and their latest versions of two very successful machines which have been introduced in recent years, all of which are the product of their extensive development programme.

The first of the new designs is a low-priced toolroom or production jig-borer, model 1520. The worktable capacity is 15 in. by 20¾ in. and the machine is provided with twelve spindle speeds ranging from 67-3,000 r.p.m. In addition to the usual course and fine hand feeds, three up and down power feeds of 0·0015 in., 0·003 in. and 0·006 in. per revolution of spindle are provided. The choice of three manual co-ordinate setting systems are offered, all of which give an accuracy of 0·00005 in. The systems are:

(a) "Newall" roller measuring system.

(b) Precision screw and vernier dial.

(c) Optical setting.

The second of this series is their spacematic 1520, of similar capacity, combining precision milling with jig-boring. In addition to hand setting, the "Airmec" automatic measuring and control system is fitted.

The third machine, model 1520 cc, incorporates the A.E.I. "Helixyn" system for continuous numerical control of three movements. Whilst this machine was designed specifically for automatic control, it has identical capacity and mechanical features of the standard unit, model 1520. Magnetic tapes are prepared from drawings and data, supplied by the user, at a computer service division provided by the A.E.I. organisation. Information is supplied by the tapes to the system and comparison of the actual and required position is made by capacitive measuring elements which feed back signals to the servo systems controlling movements of the three major slides. The system is designed to eliminate cumulative errors, permit use of various sizes of cutter which differ from the nominal, and to provide switching systems for spindle speed variation and traverse rates, etc.

Their spacematic 2657 has now been developed to provide facilities for tracer controlled copy milling, automatic staircase milling and an auxiliary horizontal work spindle. Automatic selection of three ordinates is obtained by the B.T.H. control system which is applied to the quill, table and cross-slide. This machine, one of the most highly developed of its type in the world, is shown fitted with the co-ordinate setting equipment in Fig. 2.

Model 2443, which concludes their display of jig-borers, provides a stepless speed range from 0-2,500 r.p.m., with four up and down power feeds and also table milling feeds.

The **Lindner** LB12 optical jig-borer shown in Fig. 4 will be exhibited by the Stedall Machine Tool Co. The optical measuring system contains a cylindrical measuring scale, fitted to each co-ordinate table, which can be rotated but cannot be moved axially. Each scale is mirror finished and diamond scribed with a thin helical line. By turning the scale the division can be set in increments of 0·0001 in. and an accuracy of 0·00004 in. is claimed. Spindle speeds are infinite variable from 60-3,000 r.p.m.; movement of table 16 in. and 10 in. in longitudinal and transverse directions respectively. Maximum distance between table surface to bore spindle is 16¼ in. and vertical adjustment of spindle head is 7½ in.

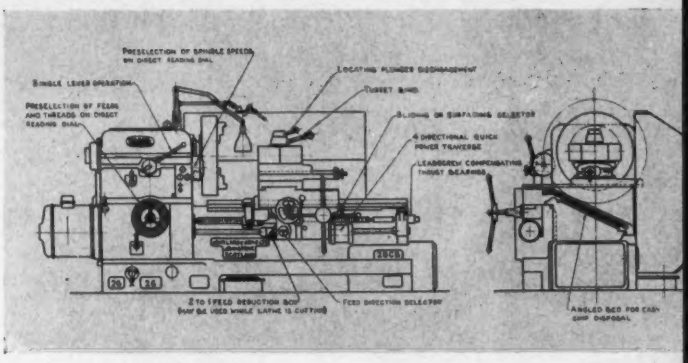


Fig. 3. Lang Gisholt 26 C.B. surfacing and boring lathe.

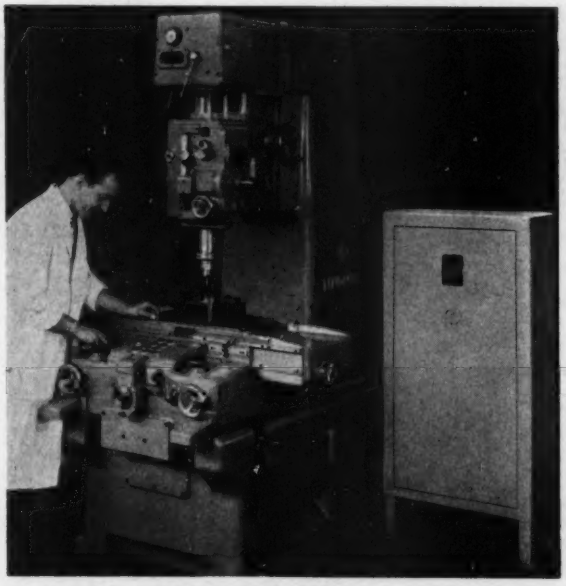


Fig. 4. Lindner LB12 optical jig-borer.

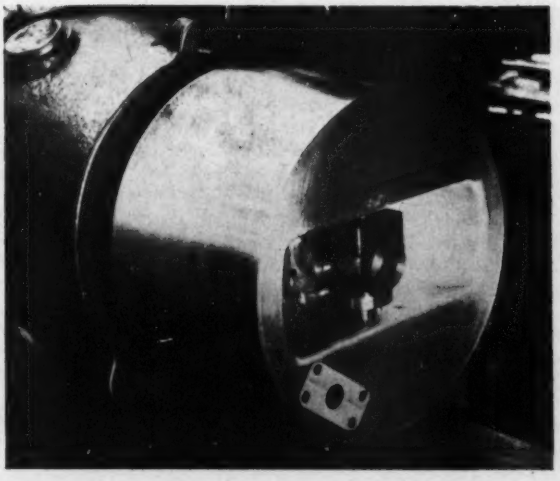


Fig. 5. Lang Gisholt auto-indexing chuck.

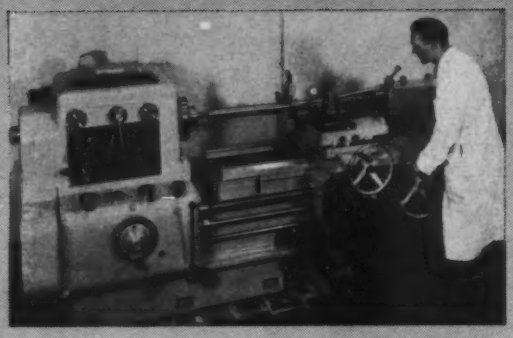


Fig. 6. Willson 11-in. or 12-in centre lathe.

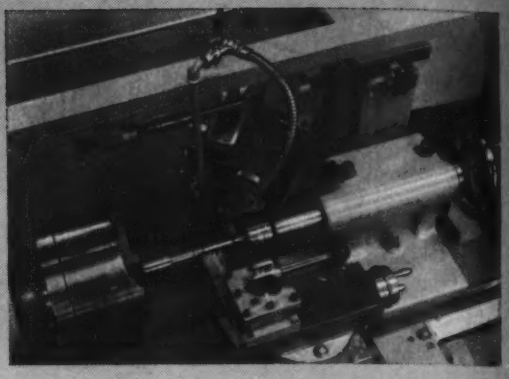


Fig. 7. Willson 6½-in. centre lathe fitted with hydraulic copying equipment.

Fig. 8. Newall ANL automatic tap grinding machine.

Horizontal Boring Machines

H. W. Kearns will be exhibiting for the first time their new model 451 P machine equipped with their optimetric system for co-ordinate setting. A 7½-h.p. motor is fitted and 27 spindle speeds can be obtained. Table size is 30 in. by 30 in., and the maximum distance from facing slide to boring stay is 48 in. Design features of their machine include the longitudinal screw and shaft, together with their associated mechanisms, submerged in an oil bath in a central bed channel running directly under the centre line of the travelling spindle. The central guide on the saddle slides in this bed channel, whilst the outer ends of the saddle are carried on large precision rollers mounted on anti-friction bearings.

Before finalising on the design of this bed and saddle system, a survey of typical workpieces, their weights, positions of centroid, etc., was carried out, followed by a combined experimental and design study of the forces, weights and couples, etc. Bearing in mind the wide variety of workpieces which such machines have to cope with, the resultant variation in bending moments, etc., encountered in positioning the workpiece from side to side, a careful choice was made of the positioning of structural members. An important feature of this new machine is the Kearns hydraulic tool release and clamping system on the main spindle which facilitates quick and accurate tool changing.

On show for the first time in this country will be the latest version of the 3 WB machine, which was specifically designed for two-dimensional automatic co-ordinate setting. The A.E.I. automatic co-ordinate setting system operates the vertical traverse of the spindle slide, and the transverse movement of the main table, which measures 48 in. by 108 in., and is designed for workpieces weighing up to 6 tons. This machine is also fitted with their hydraulic tool release and clamping system.

Lathes

Lang Gisholt Machine Co. will be exhibiting for the first time their new Lang model 26 C.B. surfacing, boring and screwcutting lathe, illustrated in Fig. 3. Whilst developed originally from their very successful model B centre lathe, first introduced at the last exhibition, the new machine was extensively tested in prototype form both under extended production line conditions and under controlled scientific experiments. To utilise the full 20 h.p. of the motor on the large workpieces likely to be encountered on the machine, the structural design is highly developed. Amongst the general features of the machine is an angled bed with the working surfaces completely covered with stainless-steel guards. Twenty-four preselected speeds are available ranging from 6·5-684 r.p.m., and a wide range of preselected feeds and threads are provided. The substantial hexagon turret can be rotated easily by hand, the weight being taken on a ball thrust bearing when the clamp is released.

A new version of the Lang model 8B2 will be exhibited for the first time. This machine is fitted with the Unitrace profiling and automatic screwcutting equipment. Maximum distance between centres when profiling is 66 in., and swing over saddle and bed are 11 in. and 20 in. respectively.

Also on show for the first time is the new Lang auto-indexing chuck, a very interesting development in chucks which is shown in Fig. 5. It is designed for machining branches at 90° to each other in pipe fittings, etc., and the workpiece indexes and locks whilst the spindle is running. Air-operated, the chuck can be fitted to an existing machine in the same way as a conventional air chuck. Indexing is by hand-, foot- or turret-operated valve.

Denhams Engineering will be exhibiting for the first time their new BV.32 lathe, the largest of their exhibits. There are many new features on the lathe, including provision for a wide selection of speeds to suit customers' requirements.

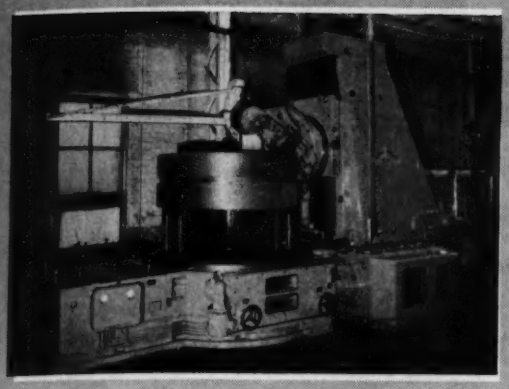


Fig. 9. David Brown 140-in. ultra-precision turbine gear hobber fitted with the "Emisyn" control system.

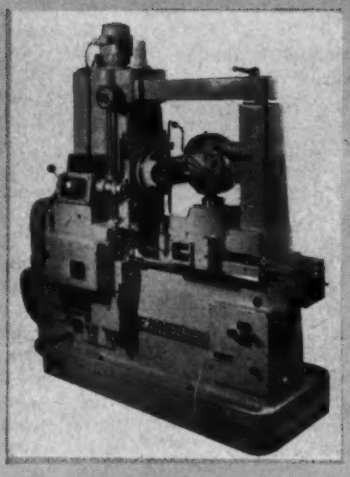


Fig. 10 (centre). Sykes HV14A universal hobbing machine.

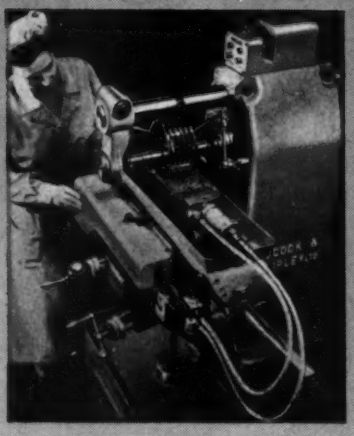


Fig. 11. Adcock & Shipley No. 1 air-hydraulic milling machine.

Twenty-four spindle speeds are available in the range 7·5-600 r.p.m. or 4·9-400 r.p.m. On this latter range a belt drive can be provided to the spindle to give twelve additional speeds up to a maximum of 800 r.p.m., thus providing facilities for high-speed finishing cuts, ceramic turning or boring operations.

Special features of this lathe include the latest developments in structural design, particularly at the bed-headstock junctions to ensure maximum dynamic and static stability, high-duty grade iron for the bed with chilled vee and flat slides having a hard and close-grained structure. The standard version utilises a straight bed solid to the floor, but a half-gap piece and hardened and ground slideways can be supplied as extras. Precision motion on the cross-slide is ensured by the use of a recirculating ball assembly on the screw and nut, and a ball bearing thrust arrangement takes the end thrust. Swing over saddle and bed are 23·5 in. and 32 in. respectively. With the gap bed version a swing of 54 in. is achieved. Length of standard bed is 13 ft. 6 in., but alternative one-piece beds can be supplied ranging from 11 ft. 6 in. to 25 ft. or with jointed beds to suit customers' requirements.

They will also be showing the latest versions of their model SR 10V 25-in. swing and model SR 8V 17-in. swing lathes.

Willson Lathes Ltd. will be exhibiting several lathes with centre heights ranging from 6½ in. to an entirely new machine of 14 in. The 11 and 12 in. centre heights have been completely redesigned and an example is shown in Fig. 6. Eighteen spindle speeds are available in the choice of two ranges: namely, 12-600 r.p.m. or 21-1,000 r.p.m. driven by a 15-h.p. motor. Three versions of their 6½-in. centre lathe will be shown, including a hydraulic copying version in which the template is situated in an overhead position in full view of the operator, as can be seen in Fig. 7.

Grinding Machines

The **Churchill Machine Tool Co.** will be exhibiting their new heavy-duty roll grinding machine, model TWA, 32 in. by 192 in. This range of machine also includes the TWB and TWR of 42 in. and 62 in. diameter capacity, built in various lengths to suit customers' requirements. The beds of the two machines are in two sections, bolted together, one for the traversing wheelhead carriage and the other for supporting and rotating the rolls. A 40-h.p. variable speed motor drives the wheelspindle and a 15-h.p. motor is used for the workhead. Duplicate sets of controls are provided, one located on the wheelhead carriage platform and the other located on the workhead to facilitate setting up the roll. Hand adjustment is also provided.

Included in the features of this machine are pressure switches in the lubrication system which operate should the lubrication system fail, the Churchill patented mechanism for producing both convex and concave cambering, and also an automatic electronic feed device which permits a constant high metal removal rate to be followed by a precision very fine feed to give a good finish.

Newall-Keighley will be featuring several new machines in their range of grinding machines. As with the other types of machines produced by the Newall group, extensive testing using latest model research techniques, for example, has been used in developing the prototypes. Consequently, many new highly developed features are included, including some unique bed structures representing a considerable advancement in the design of grinding machines.

Two new L.A. cylindrical grinding machines will be shown, one a conventional type of 16 in. by 20 in. capacity, and the other a new unit-built plunge grinder. The unit machine departs from standard practice by dispensing with the table traversing mechanisms, resulting in considerable economies in floor space making it a very attractive proposition for a production line. Many alternative arrange-

ments of workheads, wheelheads and tailstocks are possible which, together with right, or left-handed versions, have been specifically designed to meet the requirements of the modern automobile production line for example.

Another new plunge grinding machine, model B6, is offered, again with no table traverse. This machine was originally designed for high-precision plunge grinding of ring-type components such as the tracks of ball bearing inner rings, with particular regard to the necessity for high accuracy of repetitive grinding without the use of contact gauging, but which can be fitted if required by the customer. Other features include recirculating roller slideways for the wheelhead and wheel dresser, pre-set dressing, automatic compensation, etc. All hydraulic and electrical control gear is to American "J.I.C." standards, and hydraulic valves are mounted on jig-drilled manifolds for interchangeability.

A new version of the Newall tap grinder to be exhibited is the model ANL, shown in Fig. 8, which is automatically controlled to give high-speed production. Totally enclosed, the machine automatically loads, locates, grinds, ejects, gauges and dresses the wheel until the magazine is empty, then stops and displays both visible and audible signals. Other features include built-in temperature control for the spindle lubrication system, and automatic pantograph diamond dresser or wheelcrusher. A new development in sizing is embodied which consists of a diamond wedge sizing device operating on the flanks of the wheelthread. Integral with the diamond is a very sensitive "pick-up" transducer element which transmits accurate signals of wheel wear to the automatic dresser. Very close tolerances of the wheel can be held in this manner.

Landis-Lund will be exhibiting their popular type MPB 12/24 plain cylindrical grinding machine, equipped for multi-diameter grinding of automobile stub axles; three diameters are plunge ground to a tolerance of 0·0005 in., and sizing is either visual or automatic, fitted as an alternative. For crankshafts, provision can be made to accommodate wheels up to 36 in. diameter. The wheel is driven by a 20-h.p. motor and a variable speed motor having a speed range of 10 to 1 augmented by stepped pulleys drives the workhead.

Amongst their exhibits will be two American Landis-designed machines built at the Precimax works in Cross Hills. These are the 5-in. type automatic camshaft form grinder and the 16-in. DH, automatic crankpin grinding machine. A camshaft and crankshaft will be ground on these two machines respectively for visitors to see. Such features as the Landis tool microfeed operating in conjunction with automatic sizing by means of a pneumatic electric contact gauge, and the new Landis tool R, Tru-form wheel dressing attachment will be seen.

Brown & Sharpe Ltd. will be showing four American-manufactured machines; the No. 13 universal and tool grinder, a newly designed No. 5 plain grinder, and for the first time on show in England the 510 surface grinder and the No. 618 Micromaster surface grinding machine fitted with visual grinding aid.

When using the visual aid, the operator manipulates the grinding wheel along the workpiece until the image coincides with the pencilled outline on the translucent screen. The entire optical system moves as an integral unit with the workpiece to maintain sharp image focus; thus stop and start grinding is eliminated and continuous grinding and inspection of intricate shapes are possible.

Milling Machines

Midgley & Sutcliffe will include in their exhibits their completely new No. 5 heavy vertical milling machine, which embodies several new features including a body structure of advanced design in order to take full advantage of a 20-h.p. motor when using the latest types of cutting tools. A new design of gearbox is used incorporating B.H.I. multi-disc electro-magnetic clutches controlled by a single switch. The feed mechanism, which will only be available to the table, is hydraulic, giving a range of 0-200 in. per min. Spindle speed range is from 200-2,500 r.p.m.

Also new is their No. 3 vertical machine, developed from their popular No. 3 plain and universal miller. It is equipped with a 7½-h.p. motor, and employs a speed range of 40-2,000 r.p.m. Table size is 48 in. by 11 in., and a swivel angle of 45°, right or left, is possible on the head.

Five other machines will be shown, including their standard turret milling machine fitted with a new type of "Hyspeed" milling attachment incorporating power feeds to the quill, and also fitted with optical measuring equipment.

Centec Machine Tools will be exhibiting their recently-introduced No. 2B hydro-pneumatic milling machine. A table traverse of 12 in. horizontally and vertically is provided and for automatic production it can be set for fast approach, pre-set cutting speed and automatic fast return. Other exhibits will include the 2A and 2B machines and the Centec 3 series programme-controlled milling machines and profile milling machines.

Adcock & Shipley will be exhibiting a full range of machines, including their new No. 1 air-hydraulic machine shown in Fig. 11. It is fitted with an interlocked safety start mechanism which ensures that both the operator's hands are in a safe position when the automatic cycle commences.

Gear Production Machines

W. E. Sykes will be exhibiting several new machines or features amongst their range. On public demonstration for the first time will be the Sykomatic VB 10 turret-loading internal gear generator producing a 42-tooth 27° H.A., internal gear of approximately 14 N.D.P., face width 1⅞ in. A six-station turret is used and total production time is 6 min. per component. Pitches up to 5 D.P., blank diameters up to 5 in. straight or helical gears of either hand up to 45° H.A. can be accommodated.

Also exhibited for the first time will be their model HV 14A universal hobbing machine shown in Fig. 10.

David Brown will be exhibiting two methods of producing large hobbed gears on machines of 140 in. and 30 in. capacity respectively. Their 140-in. ultra-precision turbine gear hobber shown in Fig. 9 is equipped with the "EMISYN" control system which provides a continuous check on indexing accuracy and compensates for cumulative errors. A resolver, driven by the worm shaft, produces an electrical signal which is compared at an inductosyn mounted in the centre of the table. Any errors introduced by the master wheel and gears in the mechanical drive are signalled continuously through a servo-motor and correcting mechanism. Thus errors due to mechanical wear will be automatically corrected throughout the life of the machine.

The inductosyn consists of two glass discs, rotor and stator, each of which has a silver pattern on one face. The pattern on the rotor forms a continuous printed type coil of 360 radial lines, the two ends of which are connected to the control console through a slip ring and brush unit. The pattern on the stator has sixteen sections, each consisting of a printed-circuit type coil of sixteen radial lines. The rotor and stator, with appropriate wiring, forms a 360-pole inductosyn. Correction is imposed on the worm drive by axial displacement of a helical gear with respect to the mating gear. The axial displacement is derived from a recirculating ball nut and screw, driven through a spur gearbox from a 100-watt servo-motor. A correction of 0·00025 in. at the master wheel is obtained by a 0·1 in. axial displacement of the helical gear. Accuracy is no longer dependent on the master worm wheel, but is derived from the inductosyn, the maximum error of which is better than ±2 sec. of an arc.

designer's notebook

An Unusual Angular Transmission

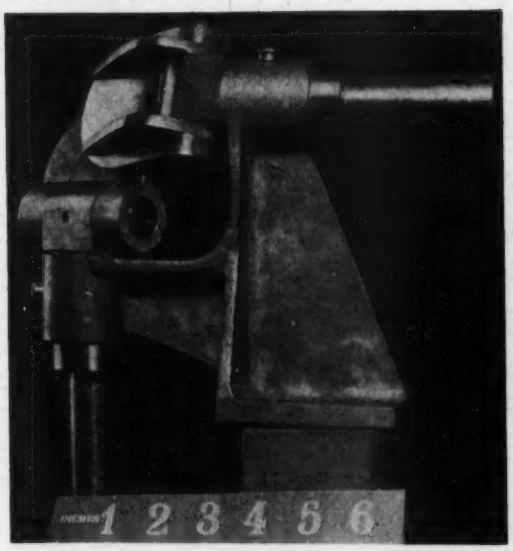
KINEMATICALLY, universal joints can be divided into two classes, the Hooke's or Cardan joint and the constant velocity joint. It is well known that the normal type of universal coupling produces periodic fluctuations in the torque and speed ratio, increasing with the angle of inclination of the shafts. Such speed and torque variations are not always acceptable. It is not always possible to introduce two joints to compensate for such variations.

The relatively complicated Rzeppa and Chobham couplings, which provide constant-velocity characteristics, are normally restricted to applications such as vehicle transmissions. A single universal joint, moreover, can only accommodate an angle of about 20 deg.

Although bevel gears for shafts at right angles are almost universal, it is necessary to cut special bevel or skew gears for special angles.

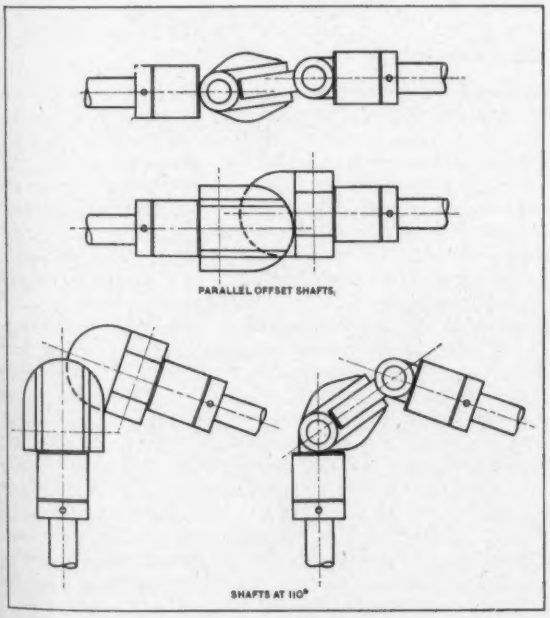
A transmission which avoids the drawbacks of universal joints and gearing for angular transmissions, now being made by Peckett & Sons Ltd., is illustrated. It is shown in the photograph in a form arranged for a right-angled drive, and in the drawings for parallel offset shafts and shafts at 110 deg.

Each shaft has a T-shaped head which is drilled transversely for a steel pin. On each pin is mounted a driving member, free to swivel through a total angle of somewhat more than 90 deg. One member, the fork, is of cast bronze, and embraces the other member, which is a steel tongue. Both tongue and fork are machined to provide minimum backlash. The transverse pins work in p.t.f.e.-impregnated bushes pressed into the bored bosses of the two members, so that no lubrication of the joints is required. The pins are retained in position by spring dowel pins. P.T.F.E.-impregnated thrust washers are fitted on each side of the bracket-bearing bosses.

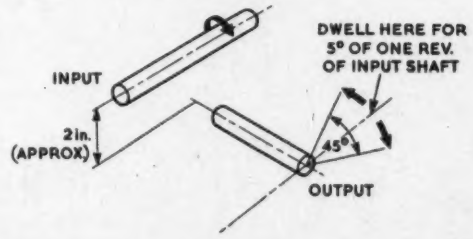


Advantages claimed for this joint include the following: A uniform angular velocity ratio of 1 : 1 between the driving and driven shafts is maintained at all angles. Where the shafts are parallel, but considerably offset, the angular velocity ratio is still uniform. The transmission will work over the very wide range of shaft inclinations from zero to 110 deg. The sliding surfaces of the tongue and fork have a greater area than the tooth contact area of a comparable bevel gear. The area in shear is greater than that of the engaged teeth of the comparable bevel gear. The transmission is virtually silent.

T. Fursdon Crang, Ph.D., M.Sc. (Eng.)



PROBLEMS IN DESIGN



Devise a mechanism which will cause a rotating input shaft to reciprocate angularly an output shaft, at right angles and approximately 2 in. below it, through an angle of 45 degrees. At the mid-point of the reciprocation the output shaft must have a dwell period of 5 degrees of rotation of the input shaft. One revolution of the input shaft must cause one complete reciprocation of the output shaft. Reciprocation shall be positive and no springs must be employed.

Best solutions to "Problems in Design" are published and paid for. Send your solution for this month, with a drawing or diagram (in Indian ink and not more than 12×12in., please!), to The Editor, "Problems in Design No. 9 (July)". Closing date August 15.

PROBLEMS IN DESIGN

Problem No. 6 (April). Devise a mechanism whereby an input shaft, rotating unidirectionally, shall drive an output shaft at half its own speed and at the same time cause it to perform one complete reciprocation for each one of its own reciprocations.

Owing to an error, the above problem was ambiguous. The last word should be "revolutions". Most of the entries received were based on the correct assumption that this was the case. Two very ingenious entries, however, were submitted as solutions for the quite different problem presented by the literal acceptance of the problem as worded above. We are glad to include both of these, although they come from the same reader.

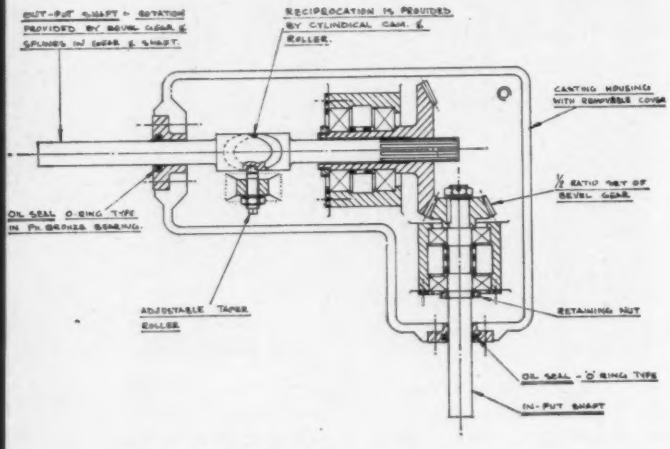
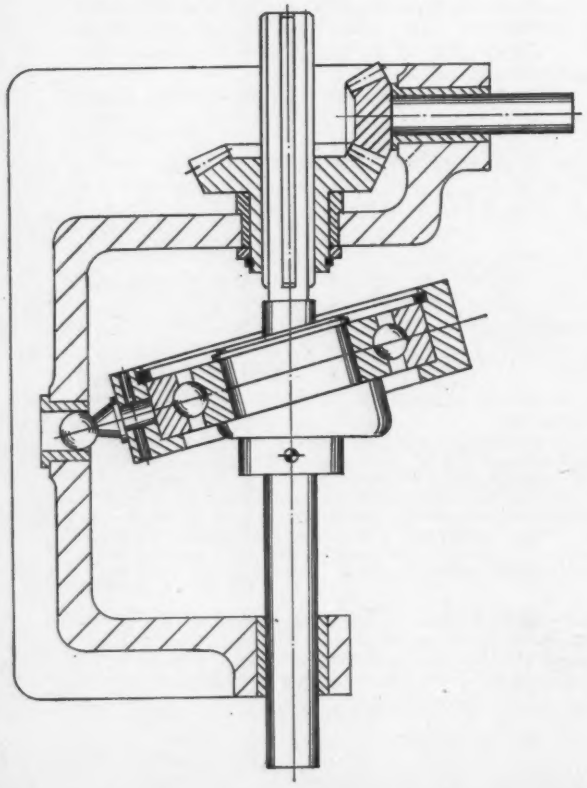

OUT-PUT SHAFT & ROTATION PROVIDED BY BEVEL GEAR & SPLINES IN GEAR & SHAFT.
RECIPROCATION IS PROVIDED BY CYLINDRICAL CAM & ROLLER.
CASTING HOUSING WITH REMOVABLE COVER
½ RATIO SET OF BEVEL GEAR
OIL SEAL O-RING TYPE IN Ph. BRONZE BEARING
ADJUSTABLE TAPER ROLLER
RETAINING NUT
OIL SEAL - 'O' RING TYPE
IN-PUT SHAFT

Fig. 1. W. WONG

Fig. 2. J. E. POOLEY



As solutions to the problem when it is assumed that the input shaft does not reciprocate, we include the following: W. Wong (Fig. 1) employs a cylindrical cam and roller to effect reciprocation of the output shaft. To ensure that play does not develop due to wear of the cam, he has provided a taper roller with adjustment. We feel that this mechanism would be best suited to comparatively small amplitudes of axial movement and for light duties. Large amplitudes could only be achieved by increasing the diameter of the cylindrical cam. R. A. Hammersley (Fig. 3) uses a gear-driven crank and connecting rod to reciprocate his output shaft via a reduction gear. His arrangement of rollers running on machined ways, to provide torque restraint, and his use of linear recirculating balls running in splines on the output shaft, is ingenious. Our criticism of this mechanism is that two sets of reduction gears are necessary, but it is compact and well proportioned and could, with minor obvious modification, be adapted to provide a variable amplitude of reciprocation.

J. E. Pooley's solution (Fig. 2) we thought very simple and elegant. It adopts the swash-plate principle. Pinned to the output shaft is a swash-plate assembly comprising a cylindrical portion on which is mounted a ball bearing whose axis is at an angle to the shaft. A cylindrical housing fitted to the outside of the ball bearing carries a ball-ended spigot. This spigot constrains the outer race from rotary movement by a bush in the fixed housing of the mechanism, in which it is free to both slide and perform slight movements about its own axis. To avoid line contact it might have been better to have employed a cylindrical spigot sliding in a ball end bearing.

Alternative Solution

The two alternative solutions to the problem, when it is assumed that the input rotation is accompanied by reciprocation, came from H. Tooby (Figs. 4 and 5). Both of these deserve very careful study, as they would appear to offer solutions to the kind of problems encountered in remote handling equipment. Fig. 4 employs an internally cut gear in the form of a spool, the outside of which is grooved with a circular rack which engages a spur gear. Rotation of the spool drives a pinion which, via a bevel gear, drives a similar internally cut and externally grooved spool on the output side. The internally cut gear teeth in the two spools are of considerably greater length than those of the spur gears they engage. With this arrangement it is possible to bring about either simple 2:1 reduction bevel drive, or to accompany this by reciprocating movements of the input and output shafts. The circular racks on the internally cut gears mesh with the spur gear to turn the reciprocating movement through 90 deg. In his second solution, which could be used to accompany rotary motion with much greater reciprocations of the input and output shafts, Mr. Tooby employs gears and chains. An advantage of this arrangement would be that the input and output shafts could be at angles other than 90 deg.

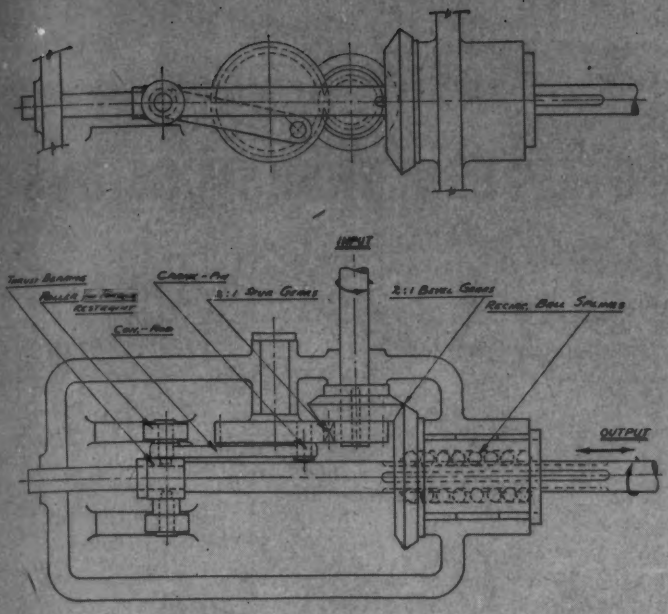
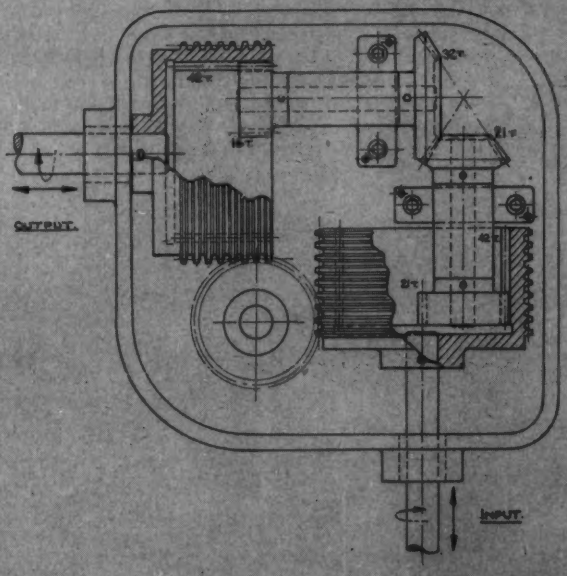


Fig. 3 R.A. HAMMERSLEY

Fig. 4 H. TOOBY., A. M. I. Mech. E.



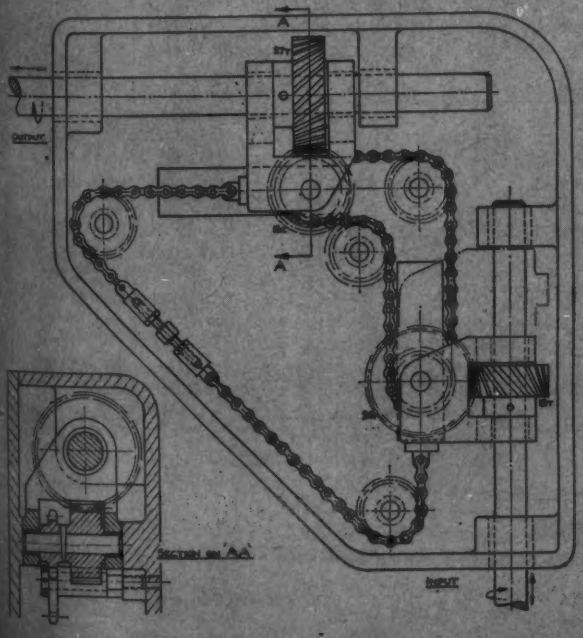


Fig. 5 H. TOOBY., A. M. I. Mech. E.

HYDRAULIC STEPLESS TRANSMISSIONS

PART 2

A continuation from our June issue of the review of various forms of fluid-operated stepless transmission units, giving details of sizes and other useful data

by W. E. LOCKE *

Ina Needle Bearings Ltd.

In the Hydrina range of high-pressure pumps are gear-type pumps, in each of which one wheel is supplied with internal gear teeth. The feature of the pumps is said to be their special tooth system with slightly convexed tooth flanks; they not only touch on one small line, but also on a comparatively broad strip, and there is consequently a good oil film between the tooth flanks.

The pump is self-priming and there is said to be very little loss through oil leakage. It may be directly coupled to electric motors running at normal speeds.

TABLE II

	Pressure p.s.i.	Delivery gal./min.	Speed r.p.m.
Pump Units FUP 50/400 FLP 250/40	711 3,550	88 8·8	1,000 1,440
H.P. Pump FUP 400/80	5,680	17·6	1,440
Dual Pump FUP 50/30–100/15	711 1,422	6·6 3·3	— —
Change-over Pump FUP 30/200/140/25 changes to	427 1,991	44 5·5	— —
Hydraulic motor 6/4/57	711	Max. torque 4,150 lb.ft.	100 (forward) 150 (reverse)

Integral Ltd.

After many years of successful development with hydraulic pumps and motors for aircraft, Integral Ltd. have produced a series of two-stage pumps with a combination of gears and pistons, operating at pressures to 4,000 p.s.i.

The basic type 180 incorporates a built-in off-loading mechanism which progressively unloads the pump with increasing line pressure, over a narrow pressure band below the maximum operating pressure. At maximum pressure the delivery ceases, and the pump continues to run while absorbing only the power required to overcome internal friction, and to circulate cooling fluid through a by-pass at very low pressure.

This two-stage pump comprises a first stage of two meshing gears, and a second of seven free pistons, working in radially disposed cylinders and operated by an eccentric driving ring, as shown in Fig. 15. The first stage feeds the second at a relatively low pressure, and has a delivery greater than the second stage which delivers at high pressure. A relief valve relieves the first stage of its excess delivery, and an off-loading valve reduces the load on the pump to a minimum when its full delivery is not required. A separate relief valve limits the pressure delivered by the second stage, and the ripple eliminator is attached to the rear end of the pump. A unique feature of these pumps is the magnetic filter incorporated in the by-pass chamber, which extracts from the internally circulating fluid any ferrous particles which may be present, thereby minimising

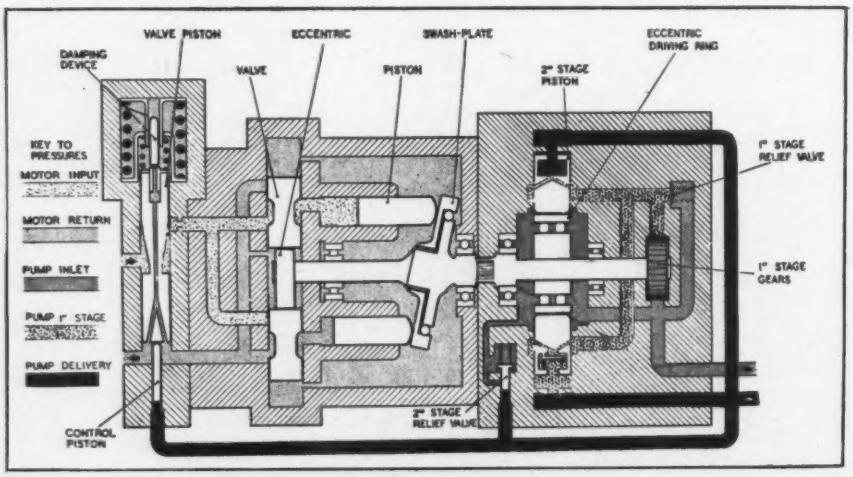


Fig. 15. Internal arrangement of Integral motor/pump unit.

* *Flight Refuelling Ltd.*

TABLE 12

PUMP UNITS	I/P rated r.p.m.	Delivery pressure p.s.i.	Flow gal./min.
Types 180 and 220 Mk. 27	3,000	2,500	3·75
Types 180 and 220 Mks. 37 and 42	3,000	2,600	5·5
Type 180 Mk. 43	3,000	2,800	5·5
Type 183 Mks. 4 and 5	4,000	3,750	7·1
MOTOR UNITS	**I/P pressure p.s.i.**	**O/P speed r.p.m.**	**O/P torque lb.ft.**
Type 197 Mk. 15	3,000	3,000	29
Mks. 1, 2, 11, 14, 16	1,500	3,000	25
Mk. 6	3,000	3,000	17·2
Type 199 Mk. 9	3,000	6,000	6·5
Mk. 6	4,000	3,000	5·6
Mks. 4, 8, 10, 11	3,000	6,000	4·2
Type 5600	May be used as pump or motor. Max. delivery as pump 4·5 gal./min. at 2,000 p.s.i. (3,500 r.p.m.). 5 h.p. max. output as motor.		

the danger of internal damage and jamming of close-fitting working parts.

The hydraulic motors type 197 and 199 are piston-type units of reversible rotation. The pistons, working in cylinders disposed around the driving shaft and lying parallel with axis of rotation, drive the shaft through a swashplate assembly. Flow of fluid to and from the cylinders is controlled by piston valves operated by an eccentric driving ring mounted on the shaft.

Both types have a high starting torque combined with excellent smooth running and creep torque characteristics, the low inertia of moving parts allowing rapid changes of speed and reversal of rotation. Typical performance curves are shown in Fig. 16.

An adaptor comprises a type 167 pump with a type 199 hydraulic motor and a control valve, the valve body being attached to the motor case. A section through this unit is shown in Fig. 15, the motor arrangement being typical of the entire Integral range. In addition to the above units, also available is a gear-type pump which may also be used as a motor with an output of 5 h.p.

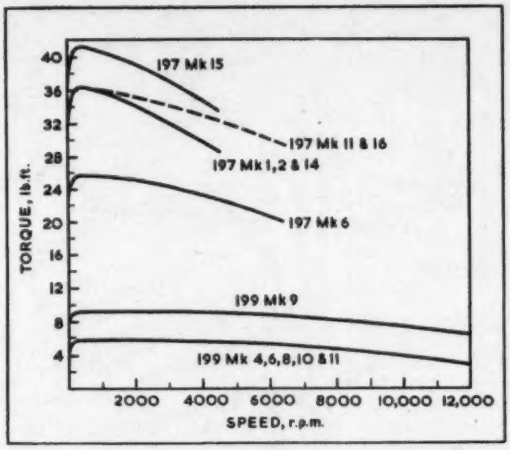


Fig. 16. Performance curves of Integral motor at 4,000 p.s.i.

Fig. 17. Sequence of operation in Keelavite rotary abutment pump.

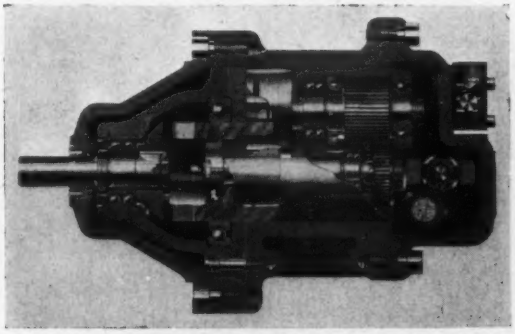


Fig. 18. Section through Keelavite variable capacity type V.548.

Keelavite Hydraulics Ltd.

In the rotary abutment range of hydraulic pumps and motors of fixed or variable capacity the basic mechanism is the same. The operating principle in each case consists of two rotating members, one of which (the rotor) is the pumping member. Two blades (B and B1 in Fig 17) project from this axially, moving in an annular space (A) about the fixed central portion (D). The other rotating part of the unit is termed the rotary abutment (C), the function of this being to maintain a seal on one side of the annular space between the inlet and outlet ports. The rotary abutment is accommodated in a recess of circular form in the fixed central portion (D), and is provided with two longitudinal recesses which receive and shroud the blades B and B1 as they pass through that part of the annulus lying between the outlet and inlet ports. There is no contact between the rotary abutment and the rotor, the correct angular relationship being maintained by timing gears.

Fig 17 shows in diagrammatic form the rotating parts at different angular positions during one revolution; Fig. 18 indicates the details of a variable capacity unit. The capacity is varied by axial movement of the rotor assembly, which controls the effective length of the annular pumping

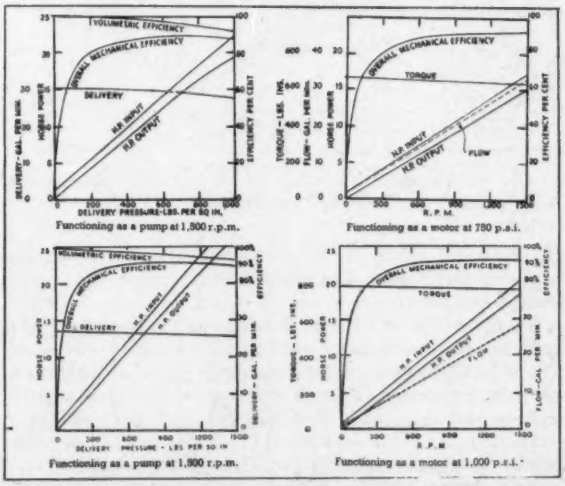


Fig. 19. Typical performance curves for type V.548 variable capacity unit (top), and type 502 fixed capacity unit (bottom).

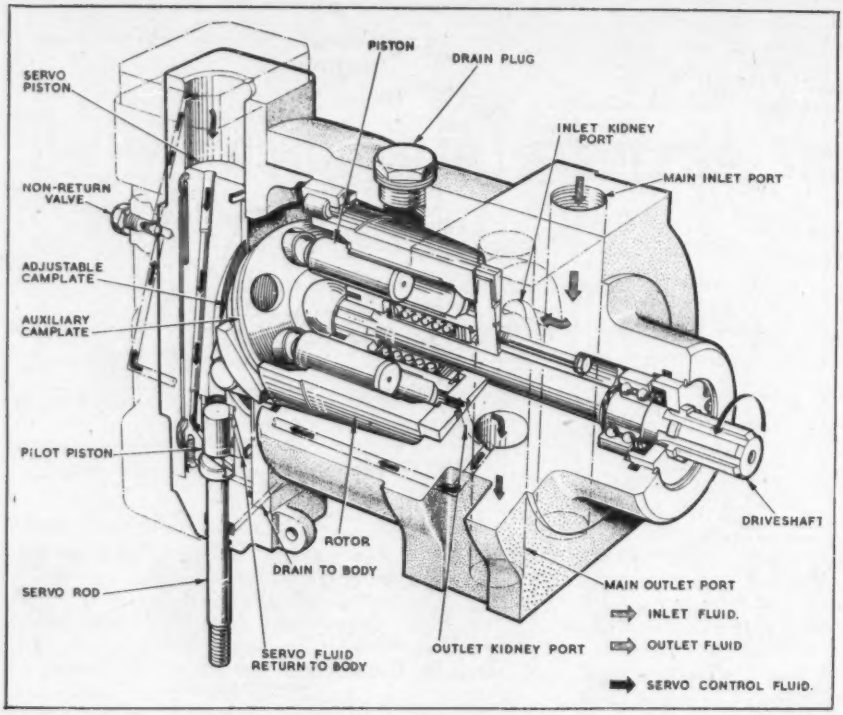


Fig. 21. Operation of Lucas typical hydraulic pump.

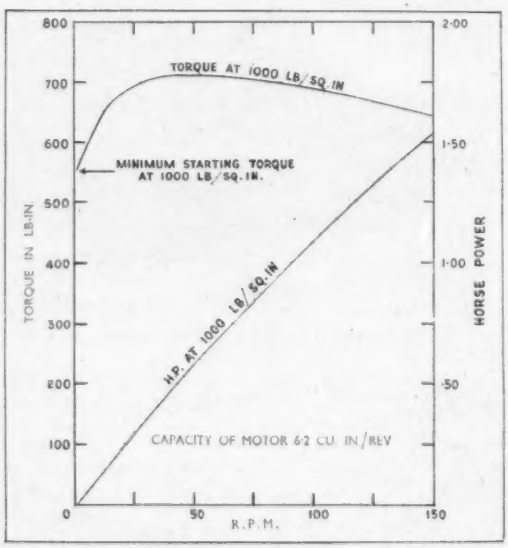


Fig. 20. Typical performance curves of Lockheed model 700 motor.

TABLE 13

	Displacement cu.in./rev.	Max. speed r.p.m.	Pump O/P gal./min. /1,000 r.p.m.	O/P torque lb. in./ 100 p.s.i.	Max. pressure p.s.i.
ROTARY ABUTMENT UNITS					
202 (Fixed capacity)	2·0	2,500	7	31·8	750
502 " "	5·0	2,500	17·5	79·6	1,500
1502 " "	15	2,500	52	239·0	1,500
V54BR (variable capacity)	0–5·5	2,500	0–20	87·6	750
GEAR-TYPE PUMPS					
G.101D	1·38	2,500	4·5	21	500
G.102D	0·69	2,500	2·25	10·5	500
G.105	1·5	3,000	5	23	1,500
G.110	3·0	3,000	10	46	1,500
G 115	4·2	3,000	15	65	1,000
G.215	4·2	2,500	15	65	2,000
G.221	6·0	2,500	21	92	2,000
G.126	7·2	2,500	26	111	1,500
G.226	7·2	2,500	26	111	2,000
G.236	10·0	2,500	36	157	2,000
G.148	13·3	2,500	48	209	1,500
G.252	14·4	2,500	52	222	2,000
G.272	20·0	2,500	72	314	2,000
G.196	26·6	2,500	96	418	1,500
G.2118	32·7	1,500	118	500	2,000
G.2145	40·0	1,500	145	628	2,000
G.1180	50·0	1,500	180	785	1,500

chamber and hence the volume swept by each revolution of the rotor blades. The rotor blades engage with axial slots in the rotating housing, by means of which the rotor is driven. At the end of the driving shaft remote from the rotor are the timing gears which drive the rotary abutment. The non-rotating centre, through which the rotor shaft runs, provides a movable end wall to the annular pumping space and, by moving axially with the rotor assembly, forms a continuous seal with the ends of the rotor blades. The other end of the annular space is provided by the cylindrical end wall of the rotating housing. Axial movement is imparted to both the rotor and the rotor centre, by angular movement of the transverse shaft, through the medium of a short lever carrying a self-aligning bearing. This latter is thus caused to move freely between the forks, which consequently transmit the required axial movement to the rotor assembly. Typical performance curves for a fixed-capacity, and variable-capacity unit, when used both as pump and motor, are given in Fig. 19.

A range of gear-type pumps and motors is also available operating at pressures from 500-2,000 p.s.i. and motor torques from 10·5-728 lb. in. per 100 p.s.i.

Leeds Engineering & Hydraulic Co. Ltd.

The motors and pumps manufactured by this company are in the heavier range, both pumps and motors being of the high-pressure radial type. Both pumps and motors are available in the larger ranges as a double-banked unit, and

TABLE 14

LEH Transmission Unit PUMPS	O/P flow, gal./min.	
	(at 3,000 p.s.i. max. at 960 r.p.m.)	
6/56	10½	
6/75	14	
9/56	15¾	
9/75	21	
MOTORS	I/P flow, gal./min.	O/P b.h.p. at 500 r.p.m.
6/112	14	22
9/112	21	33
6/216	28	44
9/216	42	66

a transmission system is available which incorporates both pump and motor as an integral unit.

Lockheed Precision Products Ltd.

The Model 700 motor houses a barrel-type cylinder block containing seven parallel and equispaced cylinder bores. Each bore contains a pair of pistons and these carry at their outer ends rollers which bear on face cams fixed to the end covers. Fluid is conveyed to and from the mid-point of each bore, forcing the pistons apart, thus causing rotation of the cylinder block owing to the oblique reaction from the cam faces. Maximum torque is 710 lb. in. at 50 r.p.m. and maximum horsepower is slightly in excess of 1·5 at 150 r.p.m. The maximum working pressure is 1,500 p.s.i. and typical performance curves are shown in Fig 20.

Model 350 has a maximum torque of 400 lb. in. at approximately 75 r.p.m. and maximum horsepower of 1·2 at 200 r.p.m. Model 1200 is slightly larger, with an output of 700 lb. in. at 1,000 p.s.i. Other pumps and motors are made to order to suit specific requirements.

Joseph Lucas (Hydraulic & Combustion Equipment) Ltd.

This range of hydraulic pumps is also available as hydraulic motors, the pumping fluid in this case driving the pistons and transmitting motive power to the drive-shaft. The pump is driven by a prime mover, and fluid is delivered to the inlet port by either a boost pump or from a header tank.

The rotor, which is part of the drive-shaft, contains the pistons, the slipper heads of which ride on the face of the adjustable camplate and are retained in this position by an auxiliary camplate. The angle at which the adjustable camplate is set therefore determines the piston stroke, and, in conjunction with rotor speed, the flow rate output of the pump.

As the pistons revolve with the rotor, they follow the path of the inlet kidney port and at the same time move farther down the cylinder bores, inducing fluid from the inlet port into the cylinder bores (see Fig. 21).

Further rotary movement brings the pistons on to the path of the outlet kidney port, and at the same time they move farther up the cylinder bores, expelling the fluid through the outlet kidney port to the outlet port at the flow rate determined by the angular setting of the adjustable camplate and rotor speed. If the adjustable camplate is moved over centre or the direction of rotation is reversed, the inlet port becomes the outlet port and vice versa. This port reversal also applies to the inlet and outlet kidney ports.

Fluid, at pump outlet pressure, is circulated to the servo control mechanism by means of internal drillings in the pump body.

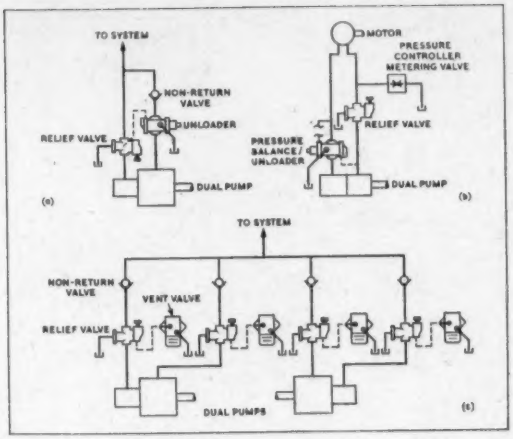
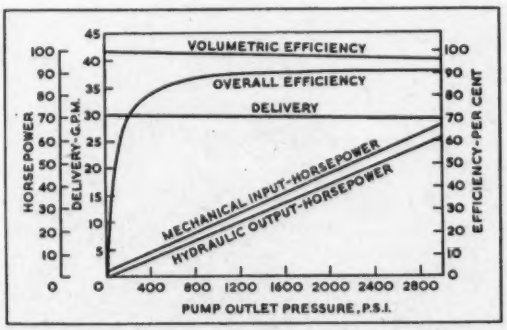


Fig. 22. Typical circuits using S.A.V. units.



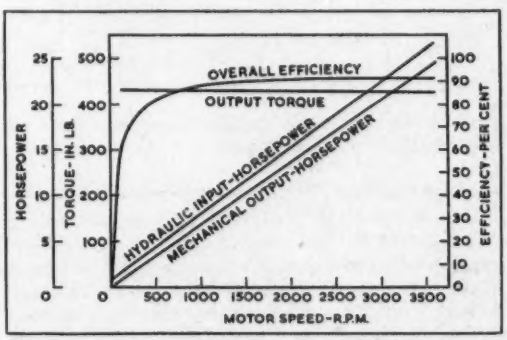


Fig. 23. Typical performance curves for pump PF-3918-30 at 3,600 r.p.m. (top) and motor MF 3913-30 at 3,000 p.s.i. (bottom).

Sperry Gyroscope Co. Ltd.

The Plessey Co. Ltd.

Recently introduced is the reversible gear-type hydraulic motor with unusually high starting torque. The motor is rated at 5 h.p. at 1,500 p.s.i. and 1,500 r.p.m. and is capable of speeds up to 3,000 r.p.m. A wide range of pumps is also

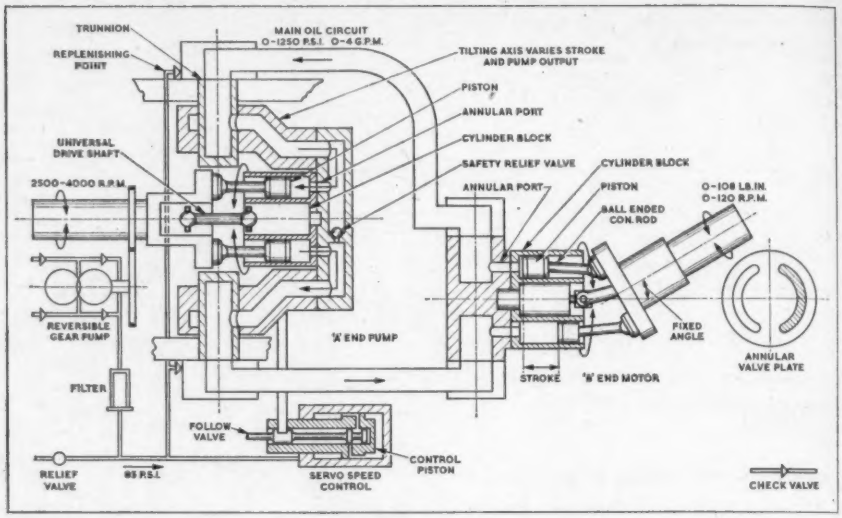


Fig. 25. Diagrammatic arrangement of Vickers Inc. aircraft unit.
(Tarvac Ltd.)

TABLE 15

PUMPS	I/P speed r.p.m.	O/P pressure p.s.i.	O/P flow gal./hr./1,000 r.p.m.
IP.60	5,000 max. 3,000 nom.	3,000 max. 2,000 nom.	60
IP.125	4,000 max. 3,000 nom.	,,	125
IP.525	3,000 max. 2,000 nom.	,,	525
IP.500	4,000 max. 3,000 nom.	,,	500
IP.1000	3,000 max. 2,000 nom.	,,	1,000
IP.3000	2,000 max. 1,500 nom.	,,	3,000

MOTORS	I/P pressure p.s.i.	I/P flow gal./hr./ 1,000 r.p.m.	O/P speed r.p.m.	O/P torque/ 1,000 p.s.i.
IP.60	3,000 max. 2,000 nom.	60	6,000 max. 3,000 nom.	39·6 lb. in.
IMH.125	,,	125	4,000 max. 3,000 nom.	6·77 lb. ft.
IMH.500	,,	500	4,000 max. 3,000 nom.	26·85 ,,
IMH.1000	,,	1,000	3,000 max. 2,000 nom.	53·0 ,,
IMH.3000	,,	3,000	2,000 max. 1,500 nom.	158·5 ,,

available to match the characteristics of motors and any associated hydraulic equipment.

Stein Atkinson Vickers Hydraulics Ltd.

The British-made Vickers-Detroit pumps and motors manufactured by this company are of the positive fixed-displacement vane type. Up to a nominal 1,000 p.s.i. the single-stage industrial pumps give ninety different fixed outputs from 1-60 gal./min. from units assembled from only three basic body forms. Seven outputs (1½-36 gal./min.) are available from two body forms in the two-stage industrial range rated for a nominal 2,000 p.s.i. maximum working pressure. A range of pumps designed as cheap expendable units (mobile equipment) for working in conditions where plant life is short gives maximum pressures in the 2,000-p.s.i. region by a single stage: here seven outputs (from 2½-8 gal./min.) are available using two body sizes. Another single-stage pump recently added to the British production is rated for pressures in the 2,000-p.s.i. region (deliveries 6-100 gal./min.) but special vane design has lengthened the life of the pump to compare with industrial units. Pump output is naturally dependent on driven speed.

Four sizes of vane motor are in British production (using two body forms) giving from 5-21 h.p. at maximum continuous speed and pressure ratings. When flow controlled, these deliver a variable horsepower while pressure control

TABLE 16

Balanced vane motors (Recommended maximum continuous operating pressure, 800 p.s.i.)

	O/P h.p.	Speed r.p.m.	Displacement gal./min.
Series M2-200	5·0	2,200	13·4
	6·3	1,800	15·0
Series M2-400	16·6	1,800	40·0
	21·6	1,800	49·5

enables a variation of torque.

Several types of variable-displacement pumps and motors are available from the American range, but S.A.V. rarely find it essential to use these units because combinations of fixed-displacement pumps or the use of metering systems are effective and economically attractive (see Fig. 22).

Sperry Gyroscope Co. Ltd.

This series of pumps and motors was originally developed for aircraft use by Vickers Inc. of Detroit, and are now manufactured under licence in the U.K. by Sperry, and fitted to a number of new British aircraft.

The Vickers 3,000-p.s.i. constant-displacement pumps are of the piston type and are available in a large range of sizes, each pump consisting of a cylinder block, nine piston sub-assemblies, a drive shaft and anti-friction bearings, all housed in a light alloy case.

The pumps are designed to deliver a continuous, non-pulsating flow of hydraulic oil, the angular position of the cylinder block with respect to the drive shaft causing the pistons to traverse their respective cylinder bores. As a piston moves away from the valve plate, the hydraulic oil is drawn through the inlet port of the valve into the cylinder bore. When the piston moves toward the valve plate, the oil which was drawn into the cylinder bore is forced into the outlet passage of the valve plate, and out into the circuit at system pressure. The nine pistons perform the same operation in succession, so that the flow of oil is continuous.

The pump housing is always full of oil and, when the pump is operating, the nominal leakage past the pistons and valve surfaces of the cylinder block maintains a positive pressure in the housing. This positive pressure prevents air from entering the housing, and ensures the lubrication of the anti-friction ball bearings and other internal parts. The housing pressure is automatically controlled by a pressure regulating valve, this being built into the valve plate. The oil from the regulating valve is routed by internal passages

TABLE 17

PUMPS	I/P speed r.p.m. cont.	O/P flow gal./min. at 3,000 p.s.i. and 1,500 r.p.m.
PF-3906-15	6,960	0·265
-20	"	0·351
-25	"	0·433
-30	"	0·514
PF-3909-15	4,440	1·027
-20	"	1·357
-25	"	1·676
-30	"	1·984
PF-3911-15	3,770	1·676
-20	"	2·211
-25	"	2·741
-30	"	3·233
PF-3913-15	3,240	2·660
-20	"	3·515
-25	"	4·342
-30	"	5·137
PF-3915-15	2,770	4·250
-20	"	5·618
-25	"	6·943
-30	"	8·213
PF-3918-15	2,390	6·575
-20	"	8·689
-25	"	10·738
-30	"	12·701

Output pressure for all units: 3,000 p.s.i.

MOTORS	O/P speed r.p.m. at 3,000 p.s.i.	O/P torque lb. in. at 3,000 r.p.m.
MF-3906-15	6,960	23·5
-20	"	31·1
-25	"	38·4
-30	"	45·4
MF-3909-15	4,440	90·7
-20	"	119·9
-25	"	148·1
-30	"	175·2
MF-3911-15	3,770	147·8
-20	"	195·4
-25	"	241·4
-30	"	285·6
MF-3913-15	3,240	234·8
-20	"	310·2
-25	"	383·4
-30	"	453·6
MF-3915-15	2,770	375·3
-20	"	496·0
-25	"	612·9
-30	"	725·1
MF-3918-15	2,390	580·6
-20	"	767·2
-25	"	948·0
-30	"	1,122·0

Input pressure for all units: 3,000 p.s.i.

to the inlet port of the valve plate.

Hydraulic balancing is utilised to limit the loading of the cylinder block on the face of the valve plate. The small differential in the areas of these two surfaces in contact limits the thrust in unit pressure to a minimum. Also the axial arrangement of the cylinders minimises the inertia forces of the rotating parts and eliminates the need for large bearings. Typical performance curves for pump and motor are given in Fig. 23.

The Vickers 3,000-p.s.i. constant-displacement motors (see Fig. 24) are also of the piston type, their function being complementary to that of the pumps. Line pressure is fed to the cylinders via the valve plate, and these in turn, by reason of their inclination to the shaft axis, cause rotation of the shaft. Full torque is instantly available on opening the hydraulic line to the motor; control of speed and reversal of direction of rotation are very simple and easily accomplished. The hydraulic motor can be used for dynamic braking, as stalling due to overload will not damage it. Operation can be continuous, intermittent, continuously reversing or stalled, without damage to the motor when protected by proper system relief valve settings. The direction of rotation is dictated by the sense of the oil flow through the motor.

Based on this type of constant-displacement pump, there are several versions of a variable-displacement type. The main difference between these and the fixed-displacement type is that the former have the piston and cylinder assembly mounted on hydraulically-balanced swivel joints which serve as pintles. The pintles are therefore not subject to unbalanced forces due to mechanical driving loads or hydraulic operating pressures.

The piston stroke—and hence the pump displacement—

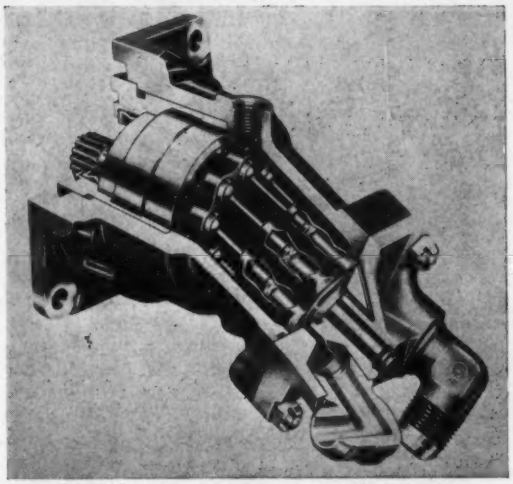


Fig. 24. Constant displacement piston type hydraulic motor.
(*Sperry Gyroscope Co. Ltd.*)

Fig. 26. Vacuum Research (Cambridge) Ltd. unit mounted with electric motor.

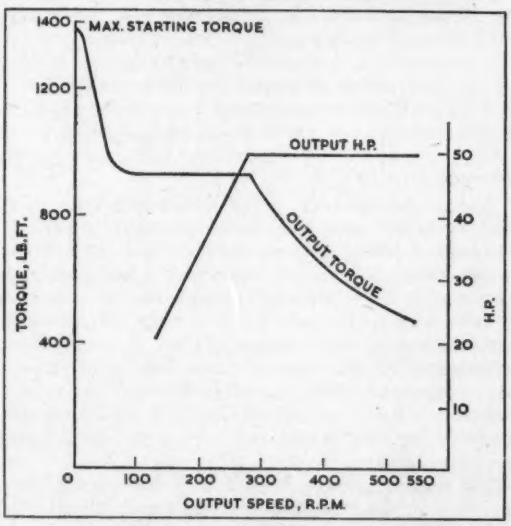


Fig. 27. Maximum duty condition of size 12 VSG motor.

is determined by the angular relationship of the cylinder block and the drive shaft axes; the larger the angle, the greater the displacement. The angle is determined by the position of the yoke, which is in turn positioned by the control element of the pump.

Hydraulic fluid enters the pump through flanges at the yoke pintles, the hydraulic balance practically eliminating wear. Passages in the yoke carry fluid to the valve plate, which ports it into the cylinders where it is loaded to rated pressure and passed back to the system.

Telehoist Ltd.

Telesig hydraulic motors are of the axial piston type made in three sizes and capable of working at a maximum pressure of 850 p.s.i.

The fixed cylinder block encloses a number of pistons disposed equally around a driving shaft and parallel with it. The pistons, which are guided in the cylinders over the whole length of the stroke, transmit their power, and impart a rotational movement, to a swash plate fixed to the driving shaft. The latter contains channels through which oil is admitted to, or exhaused from, the cylinders during rotation.

TABLE 18

Type	RM 0·5	RM 1	RM 2
Capacity/revolution	3·05	6·1	12·2
Torque (approx.) lb. in./p.s.i.	0·413	0·826	1·71
Approx. max. r.p.m.	1,000	1,000	500
Min. r.p.m.	1	1	1
Permissible Pressures, p.s.i.			
1,000 r.p.m.	400	400	—
400 ,,	525	525	525
250 ,,	650	650	650
100 ,,	850	850	850

Maximum horsepower rating is approximately 75, requiring 22 gal./min.

The speed attainable depends on the pressure available and can be obtained from Table 18. Very slow speeds are possible, down to 1 r.p.m., with a good uniformity of torque and speed. At high speeds it is not necessary to have a back pressure at the outlet; but at speeds of less than 50 r.p.m. a back pressure of approximately 30 p.s.i. ensures a smooth output, the useful supply pressure being reduced by this amount. On start-up the hydraulic motor supplies the full torque corresponding to the oil pressure. The direction of rotation is reversible and can be changed by reversal of the oil flow at high speeds and full load.

A range of pumps is available to match the requirements of these motors and any associated equipment.

Torvac Ltd.

During the last war, pump and motor units designed by Vickers Inc. of Detroit were built for U.S.A.F. aircraft gun control drives, and were mounted in pairs on a double-ended 28-volt d.c. motor running at 4,000 r.p.m. Torvac Ltd. now market these units reconditioned and adapted in various forms for industrial use. Each unit consists of a cast aluminium case containing two distinct assemblies mounted at 90 deg. to each other, i.e., an efficient axial piston pump unit delivering oil to a similar motor unit. To achieve a variable speed from the fixed capacity motor, the pump is of variable delivery, controlled by a hydraulic servo mechanism.

The axial piston pump and motor assemblies are similar in design; the operation (see Fig. 25) is as follows:

As the unit rotates, the pistons and the cylinder block rotate in unison. The pistons reciprocate, the stroke depending on the relative inclination of the piston group to the block. Oil flows into the cylinder during one half-revolution, i.e., while the end of each cylinder in turn is exposed to the annular port in the lapped face. At the top dead centre the annular port terminates and after further rotation an identical port is uncovered, into which the oil is delivered for the second half of the cycle.

In the case of the pump the angle of inclination is variable from a zero angle which gives zero stroke, zero flow and zero speed; angular desplacement from the axis in either direction produces flow in one direction or the other. The fixed inclination of the motor unit means a fixed maximum torque for any oil pressure, and this is irrespective of the speed. The drive is therefore a torque-limited unit and not a constant-power unit; i.e., the available power is proportional to the output speed.

The inclination of the pump assembly is controlled and accurately maintained by a hydraulic servo cylinder, fed by a built-in gear pump. This pump also replenishes losses due to internal leakage of oil from the main oil circuit. The external control lever actuating the servo mechanism is both sensitive and very light to operate.

A pressure relief valve built into the high-pressure oil circuit limits the pressure developed and prevents overloading, as might occur in a machine seizure.

The motor unit can be separated from the casing and connected by external pipework to the pump, and the internal pressure relief valve can be duplicated by an adjustable one, so that the torque from the motor can be adjusted at will and then performs like a slipping clutch. Two or more pump units can be used in parallel with motors either in series or parallel, the output speed being synchronised when in series and acting differentially when in parallel.

To adapt the units for use in varied ways there are a number of accessories available, or being developed.

Technical Specification

1. Infinitely variable output speed from 0-960 r.p.m. in either direction with 3,000-r.p.m. input. (Minimum usable speed: 1-2 r.p.m. running light or 3-4 r.p.m. under load.)
2. Maximum torque at any output speed limited to 108 lb. in.
3. Maximum power output, 1·6 b.h.p. at 3,000 r.p.m. input or 2·1 b.h.p. at 4,000 r.p.m. input.
4. Maximum input speed, 4,000 r.p.m. Normally not less than 2,500 r.p.m.
5. Maximum output speed, 0·31 times input speed.
6. Maximum oil pressure set at 1,250 p.s.i.
7. Weight (with header tank, full of oil, stub shaft adaptor, hand speed control), 58 lb.

Vacuum Research (Cambridge) Ltd.

In this design the variable capacity hydraulic pump and a constant capacity motor are housed as an integral unit with a maximum power output of 1·8 h.p. and a maximum output speed of 0·28 times the input speed (maximum input speed, 4,000 r.p.m.).

The stroke of the pistons in the pump cylinder block is

TABLE 19

I/P speed	O/P speed	O/P b.h.p.	O/P torque
4,000 max.	1140-0-1140 (max.) (max.)	2 max.	104 lb. in. max.

governed by the inclination of the latter which, being variable, controls the volume and direction of flow of the oil delivered to the motor. When the pump cylinder block is co-axial with the input shaft, no oil is delivered.

The motor, like the pump, is also of the swashplate type, but is fixed in its angle of inclination. The pressure relief valve in the high-pressure oil circuit limits the pressure so that the output shaft is driven at constant torque and not constant power, and permits overloading for short periods without damage.

The speed control may be operated either by a local screw

wheel, or remotely by Bowden cable or simple hydraulic cylinder, as shown in Fig. 26. Speed can be maintained constant within 2 per cent.

Vickers-Armstrongs (Engineers) Ltd.

The VSG hydraulic transmission system comprises separate variable delivery pump and motor units connected by pipelines. For certain applications the two units can be combined on a common baseplate to form a single unit with a common valve plate; this is known as the type "C" transmission gear. An advantage in having separate units is that, with a given pump, motors of varying maximum capacities may be driven from the same pump.

VSG gears are normally rated to give constant output horsepower over the upper half of the speed range, and constant output torque over the lower half. For starting purposes, a torque of approximately three times normal full speed running torque is available. A typical h.p./torque/speed curve for the size 12 gear is given in Fig. 27. In cases where the duty is intermittent, these ratings may be increased. However, where the duty is continuous, or in hot climates, cooling of the units may be necessary; it is sometimes recommended in the case of size 24 and size 50 gears. This pump is of the normal variable-tilt swashplate type, the tilt being 20 deg. on either side of a position normal to shaft axis. This arrangement permits reversal of hydraulic delivery, while maintaining the same direction of shaft rotation.

A virtual replica of this pump is used as a motor, the only difference being that the Michell-type thrust pads on the pump are replaced by roller bearings in the case of the motor. Most of these motors are of the constant capacity type in which the swashplate is held at a constant angle. For some applications, however, variable capacity units are necessary, in which case the tilt of the swashplate can be altered in the same manner as the pump.

Various methods of control are used in order to vary the tilt of the swashplate on these units, the basis being a simple lever mounted on one of the swashplate trunnions.

An automatic pressure control may also be incorporated in the pump, the standard control lever being held in the full delivery position by a spring. A ram connected

TABLE 20

VSG type C* Size No.	I/P speed, r.p.m.	Output		
		Speed	h.p. over upper part of speed range	Maximum starting torque
1/3	960 nom.	I/P-0-I/P	2½	42 lb. ft.
1	720 "	"	5	125 "
3	720 "	"	15	375 "
6	580 "	"	25	750 "
12	580 "	"	50	1,400 "
24	485 "	"	90	3,000 "
50	400 "	"	150	6,000 "

* Single unit made up from separate pumps and motors.

hydraulically to the pressure port of the pump acts in opposition to the spring, and when the pressure rises to a given "cut-off" value the ram begins to operate, the spring is compressed and the pump delivery is reduced. Any further rise in pressure will progressively compress the spring until the lever has moved the swashplate to the "no-delivery" position, and the pump is running at the stalled pressure. The pump will run for long periods in this condition, the power absorption being very low, since the only delivery is that required to make up leakage. If the pressure drops in the delivery line for any reason, the pump immediately resumes its fluid output.

For reversible drives taking advantage of the bi-directional swing of the swashplate, double-acting pressure control can be provided.

The variable delivery pump units are made in seven sizes, delivering from 5½-360 gal./min. (Imp.) at pressures ranging

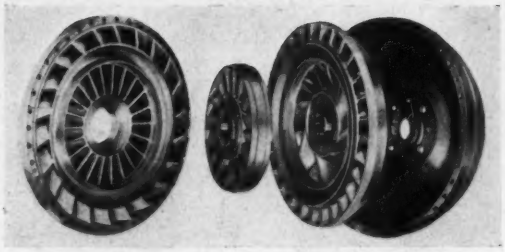


Fig. 28. Components of Brockhouse torque converter.

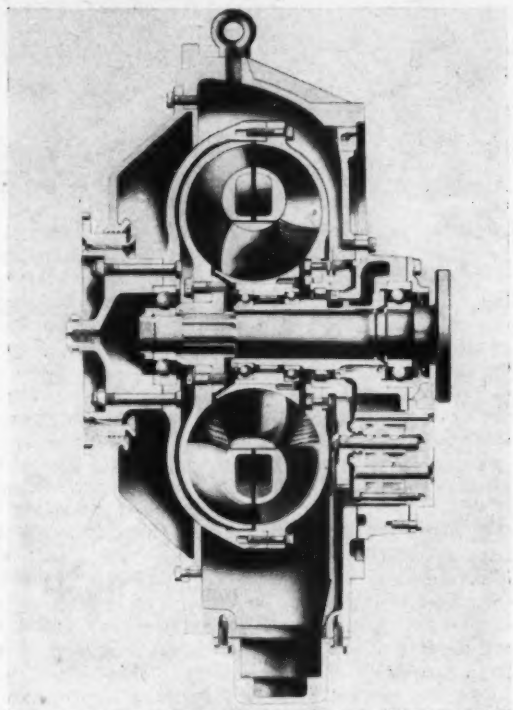


Fig. 29. Torque converter.
(Self-Changing Gears Ltd.)

from 1,000-3,000 p.s.i. Particulars and performance figures are given in Table 20; the pressure ratings given are for pumps working at full delivery, and higher pressures can be sustained at reduced deliveries.

Torque Converters

Hydraulic torque converters may be referred to here although strictly they are not variable speed units in the same sense as those previously described, for they give a variable torque transmission depending upon the load on the output shaft.

A simple torque converter consists of a driving shell, turbine, reaction member and impeller (Fig. 28), the driving case being fitted to the input shaft which together with the impeller form the fluid-tight casing. The turbine wheel is mounted on the output shaft and the reaction member is free to revolve in the same direction as the impeller and turbine, but is locked to the frame of the unit against the opposite direction of rotation.

Engine power is transmitted to the impeller, and in rotating turns the turbine due to the fluid connection. Fig. 29 indicates a typical arrangement of a torque converter.

Other makers and suppliers of variable speed hydraulic units are: W. R. Anderton & Co. Ltd., Bosch Ltd., Proops Brothers Ltd. and Weatherley Oilgear Ltd.

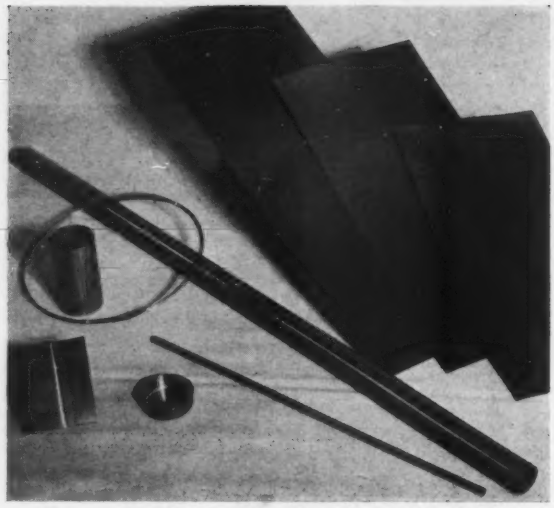


Fig. 1. A selection of niobium pieces showing the variety of forms which are possible.

NIOBIUM AND TANTALUM

This article is a general introduction to two metals which are amongst the less common materials. Practical use is now being made of their interesting properties

by T. H. H. SKEET, L.L.B.

BECAUSE of its high melting point, good corrosive resistance and strength at high temperatures, niobium has attracted the attention of designers in a narrow but important range of industries. They foresee in its properties the prospect of providing an answer for a number of metallurgical problems. Niobium is used to impart both strength and stability to ferrous and non-ferrous alloys operating at temperatures up to and exceeding 1,000 deg. C.

Niobium and tantalum share a number of properties, but both suffer the disadvantage of expensive production and of an underdeveloped market. Both metals are found together in nature in several ores. In spite of similarity in origin and substantial overlapping in properties, the two nevertheless possess distinctive properties of their own which qualify them for a growing number of uses. The consumption of both metals is, however, small compared with that of the commoner materials, and it is only recently following a series of technical changes that research generally has focused attention on the potentialities of the metals.

TABLE 1. Nuclear applications of niobium

Applications	Properties
Sheet for canning materials, for fuel elements in fast-breeder reactors.	(a) Compatibility with uranium fuel and NA-K liquid alloy coolant used to transfer heat from the reactor core. (b) Low neutron cross-section. (c) Induced radioactivity consequent on exposure to irradiation is relatively low. (d) Excellent ductility for fabrication. (e) Good thermal conductivity, facilitating the removal of heat from fuel to coolant. (f) High modulus of elasticity and creep strength. Niobium retains its shape at high temperatures. Sufficient ductility to prevent fractures at operating temperatures.
Alloy for nuclear fuel elements (90% U—10% Ni).	Suitability as a fuel-alloying element.
Structural material in reactor systems.	Excellent weight/strength ratio.
Piping corrosive liquids.	Good chemical resistance (though tantalum is preferable).
Niobium metal is also used in the form of radio isotopes in metallurgical and other research.	

Consumption in the U.S.A. is understandably much greater than in Europe, and it is evident that price is a major deterrent to a wider market. Production and fabrication of both metals and their alloys are likely to remain expensive for some time because of the need to protect them against atmospheric corrosion during sintering, melting, annealing and welding. In their favour, small quantities are sufficient to impart special properties to alloys, components fabricated even at great cost pay for themselves both by long and reliable service particularly when exposed to a corrosive source, and they have the advantage of a favourable strength/weight ratio (especially niobium). In certain instances, their particular suitability for special industrial purposes, viz., niobium in the nuclear industry and tantalum in the chemical and electronic fields, may override all other considerations. In these instances other materials present little real competition. A conservative approach would seem to suggest that the market for niobium is likely to reach somewhere in the region of 70[lb.] p.a. for nuclear purposes, while in the broader industrial field, especially for ferro-alloys, an outlet for 700[lb.] p.a. would not seem too unduly unrealistic for 1960. Niobium is expected to provide a valuable high-temperature material for aircraft production.

Niobium

Although niobium is resistant to atmospheric corrosion at room temperatures, this is certainly not the case at higher temperatures when considerable diffusion is experienced.

Slight reaction is evident at between 200 and 300 deg C., but without excessive oxygen penetration to depth. The gas, however, rapidly permeates the metal above red heat, impairing its strength through consequent embrittlement of the structure. Nitrogen also diffuses above 200 deg. C., leading to slight embrittlement. Similar results are experienced with hydrogen above 400 deg. C. with the formation of niobium hydride, although the difficulty may be overcome and ductibility restored by heating the metal in a vacuum. In fact, as niobium is reactive with all the common gases at elevated temperatures, it is essential to protect the metal from atmospheric contamination if its mechanical properties and general qualities are to be maintained. On the other hand, niobium is compatible with rarer gases such as helium, argon and neon, and it is thought that the metal's ability to withstand corrosion may be enhanced in suitable alloys, i.e., zirconium, which it is claimed will modify the protective oxide films formed, preventing diffusion of gas into the interior.

Although niobium will alloy with a number of non-ferrous metals including cobalt, chromium, tungsten, aluminium, vanadium, molybdenum and nickel with excellent mechanical properties at high temperatures, their application for industrial purposes may continue to be restricted unless a counter can be found to offset niobium's affinity for atmospheric gases.

Its distinctive mechanical properties apart, the compatibility of the metal with uranium up to over 1,200 deg. C. and liquid sodium-potassium alloy up to the boiling point of sodium, has singled it out as a most suitable cladding material for fuel elements in fast breeder reactor systems. Even in this instance care must be taken to ensure that the coolant is free of oxygen content, for above 400 deg. C. the corrosive rate of the can walls will rise appreciably.

Due to the proximity of carbon dioxide gas, niobium offers little scope as a canning material in the gas-cooled graphite-moderated reactor—the Calder Hall system of power reactors. A suitably compounded alloy could possibly be used with advantage as a structural material away from the sources of great heat, with consequent reduction in weight of the materials used.

Though the behaviour of niobium in absorbing gases is one of the factors that has militated against its broader application, this property (evident in both niobium and tantalum) may be turned to advantage in the manufacture of high-temperature high-voltage electronic valves. Pellets, strips or wire of the metals are used to absorb the residual gases in the tube, while their high melting points and low vapour pressure ensure satisfactory performance at operating temperatures.

Again, though susceptible to atmospheric gases, niobium is resistant to most acids, probably due to the presence of an oxide protective film that forms over the surface of the metal. To HNO_3, niobium is practically resistant at all concentrations; to HCl it is resistant when diluted and offers reasonable resistance to attack by the concentrated acid below 80 deg. C.; finally to H_2SO_4 the reaction is similar, though the metal is vulnerable to concentrated acid due to the ability of the latter to penetrate the protective oxide screen. In this connection niobium excels the performance of all other metals except tantalum and platinum, making it suitable for fabricating into thin liners for reaction vessels manufactured out of less-resistant alloys. Metal foil or niobium carbide is also used for lining crucibles employed to melt metals with a high melting point. For many purposes tantalum is superior, but where weight of the vessel or component is a material factor niobium has much to commend it.

The principal use of niobium is in the form of ferro-niobium and ferro-tantalum-niobium, used in the manufacture of stabilised austenitic chromium-nickel stainless steel. The addition of 1 per cent niobium to austenitic stainless steels prevents precipitation of carbides at the grain boundaries at elevated temperatures. If carbides are precipitated at the grain boundaries, the steel is embrittled. The action of the niobium in this respect is that the carbon forms niobium carbide, preferentially to chromium carbide, the niobium carbide formed being more soluble in austenite at the elevated temperature than chromium carbide. Thus the niobium carbide will not precipitate at the grain boundaries. This is especially of use when austenitic stainless steels are being welded, since there is a tendency for the carbides to be precipitated in the heat-affected zones at 650-800 deg. C. For a stainless steel to be effectively stabilised in this manner the niobium content must be ten times the carbon content.

Niobium in alloy form has a number of applications, both actual and prospective, primarily connected with the development of jet turbines, gas turbines and guided missiles. Components such as burner tunnels and ram jet-tail pipes likely to be exposed to considerable heat are fabricated from these alloys. Use is also foreseen for thin sheet for the skin or surface coverings of supersonic aircraft and missiles.

The Molybdenum Corp. of America have produced niobium-treated mild carbon steels which are claimed as suitable for replacing the relatively more expensive low alloy, high-strength steels. The fine grain structure of the product ensures high strength without brittleness, and as lighter sections may be used in heavy machinery subject to appreciable stress substantial economies in weight are achieved.

Non-ferrous alloys of niobium are many and various and include aluminium, chromium, cobalt, copper, molybdenum, nickel, tungsten, uranium, vanadium and zirconium. As the demand for the metal is a comparatively

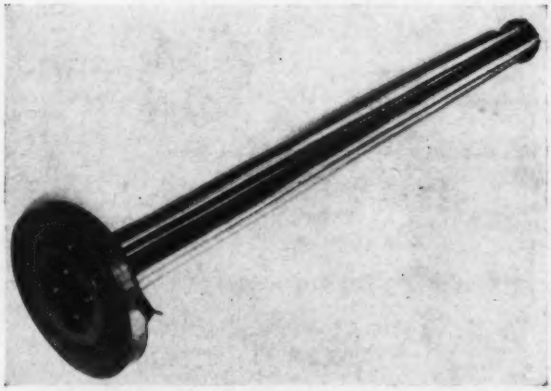


Fig. 2. Tantalum bayonet heater for heating corrosive liquids.

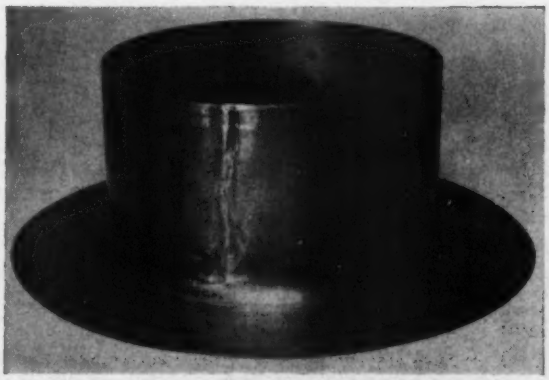


Fig. 3. Tantalum protective shield for nozzle on glassed steel tank.

recent phenomenon, fundamental research and development received little encouragement. There is thus much that is required to be known about the performance and properties of many of these alloys before their usefulness spreads from the laboratory to the workshop. Except in a number of isolated instances connected with defence, the demand for niobium non-ferrous alloys may have to await the time when niobium and associated metals become more favourable in price.

Alloyed with cobalt, tungsten and chromium, niobium is favoured for high-speed cutting tools and dies; with nickel primarily for the development of turbine blades; in aluminium casting alloys for the manufacture of internal combustion engine cylinder blocks; and with aluminium and titanium for application in the aircraft industry. As a refractory material, niobium possesses distinctive advantages over tungsten in that thinner walled seamless tubes may be drawn with greater ease; over molybdenum in that niobium due to better ductility lends to easier fabrication and over tantalum in that due to the greater density of the latter niobium offers economies in weight where that factor is an advantage. Both niobium and tantalum fabricate with equal ease.

Interest has been shown in recent years in the employment of low-melting-point liquid metals for heat transfer in nuclear reactor systems. In the Calder Hall type of reactor and the A.G.R. gas coolants are preferred, but at the experimental fast-breeder unit at Dounreay in Scotland a sodium-potassium alloy has been selected. In later years, should this latter system prove more satisfactory than other developments, niobium could achieve prominence as a canning material for a number of reactor systems employing liquid coolants, due to its compatibility with a large number of metals, including sodium, mercury, tin, bismuth and lithium. Care must, however, be taken to ensure that the coolant is itself free of impurities particularly of an oxygen source. It will be appreciated that the fast-breeder nuclear power system is not likely to reach commercial phase before the 'seventies.

For use in reactor systems it is desirable that the tantalum content should be reduced to a minimum. Separation of the two metals follows an expensive process, but ultimately a product of very high purity is obtained. The electron beam melting method of Temescal Inc. has already achieved the most promising results.

The pure metal is extremely ductile, permitting it to be cold worked into a variety of shapes required for nuclear applications. Its properties may be enhanced especially for inclusion in structural members and plant components by alloying it with other elements. Care must, however, be taken to avoid selecting metals that are liable to be affected by radiation, viz., cobalt, or by reaction with other materials at operating temperatures which in the fast-breeder reactor system is of the order of 600 deg. C. It should be appreciated that the quantity of metal required for nuclear applications will certainly be small, particularly in contrast with the amount likely to be needed for aircraft development.

Niobium is available in sheet, foil, rod, wire and tube. The metal is extremely ductile, though this will, to some extent, be contingent on its purity. Moreover, due to its affinity for atmospheric gases at higher temperatures cold working is particularly desirable when billets may be rolled, forged and swaged at room temperatures. Hot forming or heat treatment for stress relief operations are only feasible in an inert atmosphere or vacuum—the latter being pre-

TABLE 2. Main uses for tantalum

Applications	Properties
Chemical Industries	
Cladding for copper and steel pipes, HCl and other condensers, leach tanks. "Skins" for bayonet heaters for H_2SO_4.	Resistance to organic and inorganic acids; even when exposed to a corrosive source, corrosion is uniform over the broad surface of the metal, i.e., not pitted, thus permitting extremely thin sleeves to be used.
Gauze for filter screens, support screens for retaining packing, synthetic fibre cloths in filters and for anode baskets in electroplating baths.	
Heat exchangers.	Good thermal conductivity; this, coupled with anti-corrosive properties, enables extremely thin walls to be used.
Spinnerets for nylon manufacture.	Tantalum withstands the acid precipitation bath in the spinning process and is immune against alkalinous viscose.
Synthetic rubber manufacture.	Used as a catalyst.
Crucibles and laboratory ware.	Often as cheaper substitute for platinum and its alloys.
Sealing flaws for glassed steel tanks.	
Electronics	
Electrolytic capacitors	Tantalum capacitors are stable and reliable in performance over a large range of temperatures ranging from −60 to +200 deg. C. with a duration of some 10,000 hr. of service. The oxide formed on the surface of the tantalum conducts electricity in one direction only, like a radio valve.
Components of high-vacuum electronic tubes. Anodes.	At increased temperatures tantalum absorbs O_2 and N_2; thus used as a getter material in high vacuum tubes.
Anode and grid material for transmitting tubes operating at high temperatures and voltages.	High melting point and low vapour pressure.
New-type miniature electronic valve consisting of an insulated niobium wire wound around a straight tantalum wire immersed in liquid helium.	
Cryotron, for use as the basic elements in computers.	Small niobium and tantalum filaments at liquid-helium temperature have good conductance.
Electrodes in electrolytic rectifiers and high quality electrolytic condensers.	Good electric insulating properties.
Tungsten-tantalum radio valves and electrode springs.	For operating at high temperatures and maintaining good mechanical properties.
Machine Tools	
High-speed tantalum carbide cutting and machine tools and dies (e.g., for cutting and machining uranium, with which tantalum is compatible).	The carbon in steel is converted into tantalum carbide, making the alloy one of the hardest materials known.
Medicine and Surgery	
Tantalum gauze used for repairing large abdominal hernias, tantalum sutures, wires, sheet and plate for cranial repairs, bone screws and dental plates.	Resistance to attack by body acids and compatibility with body tissue, coupled with high mechanical strength.
Miscellaneous	
Precision weights. Certain metallurgical processes requiring the use of containers with high melting point. New vitreous ceramic material made of barium titanate and cadmium columbate or tantalate.	

Fig. 4. Lining for tantalum condenser.

ferred due to the difficulty in obtaining impurity-free gases. In any event, total immunity from atmospheric contamination is essential at high temperatures if good ductility is to be maintained.

For sheet rolling no difficulties are likely to be experienced and conventional equipment may be used. Foil with thicknesses down to 0·003 in. are obtainable.

For manufacturing rods and wire the same operation is followed, save that for rod rolling and swaging is substituted for flat rolling. Normally, the process is initiated using square bars. As galling may be experienced between the metal and the dies in tube drawing, a similar result is likely to be encountered in high-speed drawing of fine wire. In this instance, effective lubricants are essential.

Precision tube making (employing niobium) involves cupping and drawing at room temperatures on a hydraulic press. During the process a metal disc is pressed into a cap and drawn into a tube by conventional draw-bench methods. Before this stage is reached niobium powder is formed into bars by sintering. The product due to porosity and low ductility, however, is unsuitable for tube making. Further processing is necessary followed by rolling the bars into sheet before cupping begins. To complete the operation heat treatment in vacuum annealing furnaces may be necessary to relieve the stresses set up in the metal.

A further problem may be experienced while drawing due to galling between tube and die. This may be reduced, if not eliminated, by using tungsten-carbide, hard chrome-plated steel and aluminium bronze dies in conjunction with a suitable lubricant. Tubes fabricated from niobium cover the approximate range 0·06 in. o.d. × 0·003 in. wall to 2 in. o.d. × 0·02 in. wall.

Welding niobium presents special problems. If the argon-arc method is employed the whole operation must be performed in a sealed unit until the temperature has abated to 200 deg. C. and the gas should be driven in under pressure. While this method is preferred for sheet over 0·02 in., resistance welding is favoured for thinner metal. The speed of the operation eliminates the chance of contamination. Seam welding may be performed under water, the latter being used to absorb the heat from the weld as soon as the work has been completed.

To prevent niobium adhering to tools during machining, adequate lubrication should be used and care taken to ensure correct alignment of tools. Although CCl_4 provides the most satisfactory results, its toxicity is a significant disadvantage. A suitable alternative is Tantaroll 11.

Tantalum

While both niobium and tantalum share common properties, they do in many instances display differences in degree and distinctive properties of their own. The uses and properties of tantalum are given in Table 2. Perhaps the biggest outlet for the metal in the U.S.A. is in steel (ferro-tantalum-niobium). This occurs as a result of the close association of niobium and tantalum and the expense involved in separating them. A high tantalum content is certainly not favoured by steelmakers. In any event, the quantity of metal involved is small.

Through electrolytic reduction or alkaline metals tantalum metal is produced in the form of a grey powder. Though it can neither be melted nor cast by customary metallurgical methods, it may be pressed and sintered in vacuum at temperatures over 2,000 deg. C. Following this process a solid bar is produced which may be converted at normal temperatures into sheet, wire or tubing. Due to its affinity for atmospheric gases, annealing must be done in vacuum.

METALLURGICAL CONFERENCE

A METALLURGICAL conference was recently held at the National Bureau of Standards to present results of recent Bureau research on matters of current interest. In the past, conferences have been held almost every year to acquaint metallurgists and engineers with the progress of the work, and to explain newly developed methods for studying metals and alloys.

The first paper reviewed the advances made in the past year in developing materials suitable for extremely precise gauge blocks. This work was undertaken to provide blocks that may be certified to one ten-millionth of an inch, and recent experiments indicate that a nitrided stainless steel has many of the desired characteristics and closely approaches the dimensional stability needed in ultra-precise gauge blocks.

An explanation of the atomic mechanisms of diffusion in metals was given. When diffusion occurs by a vacancy mechanism, a diffusing atom does not make a succession of random jumps; rather, a correlation exists between the directions of successive jumps.

Recent results obtained in studies of stress-corrosion cracking of both ferrous and non-ferrous metals indicated that during crack propagation the strain rate at the tips of cracks is sufficiently high to prevent the reforming of protective films. Thus an electrochemical reaction, in which the crack tips are the anodes and the crack sides the cathodes, is important in the propagation of stress-corrosion cracks.

In the application of nuclear magnetic resonance experiments to metals, results obtained from tantalum, both in the metallic state and in a non-metallic compound, and in measurements on a series of lead-indium alloys were given.

The final speaker reported on the cyclic stressing of polycrystalline cartridge brass specimens. His experiments showed that intragranular misorientations, produced by the initial deformation and measured with an X-ray goniometer, can be reduced by straining the specimens in the reverse direction. The yield stresses measured after several deformation cycles were discussed in the light of current theories.

Particular interest was displayed in an electron probe microanalyser (see above) which promises to be useful in determining phase diagrams of alloys and in studying diffusion processes.

DESIGN OF TECHNICAL DOCUMENTS

Much has been published on the subject of technical writing, but here the author sets out in a brief and easily digested form the essential basis for a well laid out document

by F. MACHON*

EVERY engineer will sometimes have to write a report, a technical description, or something of that sort. This frequently requires excessive time and worry, and even so the author may have the unsatisfactory feeling that the job only just scrapes by. I believe that this is due fundamentally to a lack of original thought about the form of the vehicle which is to convey the information. Independent thought is expected from a designer or a research or development engineer, but when the same man sits down to present his information he often assumes unchallenged all the restrictions which are thought to govern classic prose writing.

The preparation of technical information takes on a different aspect if it is regarded as a problem in designing a device for presenting certain information to certain types of people, with complete freedom of decision about the form to be used.

The primary purpose of a technical document is to present information so that it can easily be assimilated at the first reading and easily referred to again thereafter. It may be desirable to convey an impression of competence or to be persuasive, but it is rarely necessary to display a literary style. Writers often do think that a good style is expected of them, and try to write in one by rule of thumb, but style is a result of wide reading and long practice, and a writer who hasn't developed one cannot write in it. It may be more effective to choose the pitch on which one is a professional; to concentrate, in fact, on design and organisation. Even if you have a good style, your prose may not always be what your reader wants. He usually needs specific information, and the fewer words that stand between him and it the better. It is remarkable how far one can go in getting rid of words, and though this may worry anyone who may have to edit what you write, there will be no objections from those who read it for information.

Readers Prefer Diagrams

It certainly cannot be assumed that anything that has been prepared and printed will be read from beginning to end in the intended sequence. Readers usually look first at illustrations and then, probably, at the Conclusions, the Introduction and the Contents List. If any part captures their attention, they may look it up. The work is likely to be read from beginning to end only by those who have to, or whose attention has been obtained, and want to.

So diagrams are the thing to attract borderline readers and to make captive readers happy, the medium in which many engineers have better experience than in writing, and to which engineers always turn whenever they have difficulty in expressing themselves. A diagram enables the reader to go at once to the part of the information he is interested in, whereas a written description must be read through in order to find particular facts. Further, even the most complete written description tends to omit required information unless the exact status of the readership is known, because there are so many possible points of view. Diagrams are appropriate to a wider range of types of readers, because each can see a diagram from his own point of view.

If you can present anything diagrammatically rather than in writing, therefore, the reader is more likely to find in it the information he wants, and to get it quicker and straighter.

This is not to propose merely plenty of diagrams to illustrate what has been written, as if to emphasise that the writing is not precise enough to stand up by itself. The best place for a diagram is right in its logical place in the text, unless the method of reproduction prevents it; it can be relied upon to convey the information that is in it, without any repetition in words.

Diagrammatic Design of Text

The text itself forms a pattern which clearly conveys its own preliminary information, whether the author intends it or not. The page which contains three or four rectangular chunks of text, neatly separated by paragraph divisions, indicates at once that here is solid reasoning or description, from which any specific items of information must be sifted. Often this cannot be avoided, but sometimes the words can be organised diagrammatically so as to inform the reader in advance of the method of the exposition. Thus any three or more similar items in a sentence will make a list, as follows:

Three faults developed in the pump:
1. erosion of the body at the outlet port,
2. wear at the ends of the rotors,
3. partial disintegration of the shaft seals.

More complex cases may be more obviously worth this kind of treatment when the amount of information is still hardly sufficient to justify the use of a table, as in this kind of layout:

* *Technical information engineer, D. Napier & Son Ltd.*

Ceramic annuli, ground and unground, were tested at
500 to 1,000 r.p.m.
(9·9 to 19·8 ft./sec.)
against a steel pressure plate, at load intensities of 43 to 87 p.s.i.

Ground ceramic annuli only were tested at
500 to 1,500 r.p.m.
(9·9 to 29·7 ft./sec.)
against a cast iron pressure plate, at load intensities of 29 to 37 p.s.i.

Diagrams and text are not naturally separate media, and can often be allowed to remain together, as in Fig. 1.

The Design of Tables

Tables, again, are not a separate case but a common diagrammatic arrangement of text. As with diagrams, their design presents problems which fall entirely into the competence of the engineer, but they usually require a conscious design effort and often have to be developed through several stages until the best compromise is obtained.

Fig. 2 is a fair example of an undesigned table, but attention to the design might produce the form shown in Fig. 3. This arrangement is lighter and more attractive because the dividing lines have been omitted. It avoids repetition, which is the sign of an unsolved problem in the design of a table, and its organisation is more rapidly understood.

Another example of table design is shown in Fig. 4.

Since tables are so commonly used, I offer the following summary of points which may be observed in their design:

1. Values common to several adjacent columns should not be repeated, but written across them, or bracketed, to make the similarity immediately obvious to the reader.
2. All column headings should be the same way round, so that the reader does not have to twist the page back and forth.
3. Information too scattered to justify a separate column may be injected by means of asterisks, distinguishing colours, etc.
4. Divisional lines should be kept to a minimum.
5. As with co-ordinates of curves, headings are generally more useful when written from the general to the particular. Thus:

	Speed of output shaft, r.p.m.
rather than	*Output shaft speed, r.p.m.*
or	*r.p.m. of output shaft.*

Headings to Sections

However well the information is presented in detail, the ease of reading and of use for later reference depends upon the organisation of the work in its entirety. This can best be made useful to the reader by signposting thoroughly with headings and sub-headings, and these will help the author to see whether the organisation really is good.

Headings might be designed with three purposes in mind:

1. To act as the reader's chart to the document during reading.
2. To enable any particular region to be located rapidly for reference.
3. When written together, in the contents list, to present the organisation of the work in brief.

The author has found no method better than to divide the work into its logical major sections, usually four or five, and to divide these, if required, into sub-sections and sub-sections again. These are numbered, and would appear in the contents list (to invent a specimen) as:

1. INTRODUCTION
2. THE TEST APPARATUS
2.1 Apparatus for tests in air.
2.2 Apparatus for tests in vacuum.
3. THE TEST SCHEDULE
4. THE RESULTS
4.1 Results of the tests in air.
4.2 Results of the tests in vacuum.
4.2.1 Results in vacuum at 20 deg. C.
4.2.2 Results in vacuum at 300 deg. C.
5. CONCLUSIONS

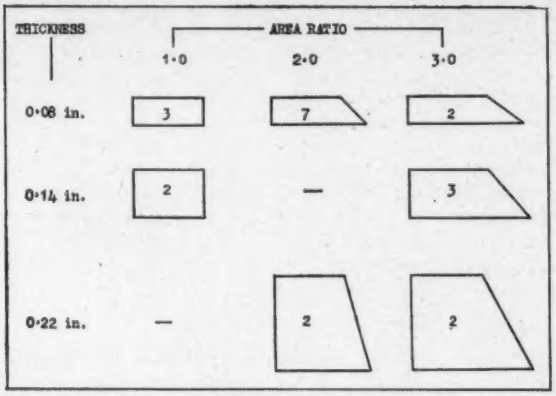


Fig. 1. Diagram and text can often be put together.

Scale Parameter = 0·6		Scale Parameter = 0·8		Scale Parameter = 0·9	
L	No. of blades	L	No. of blades	L	No. of blades
0·03	9 18 —	0·03	9 18 36	0·03	— 18 36
0·04	9 18 24	0·04	6 18 24	0·04	6 — —

Fig. 2. Example of badly-designed table.

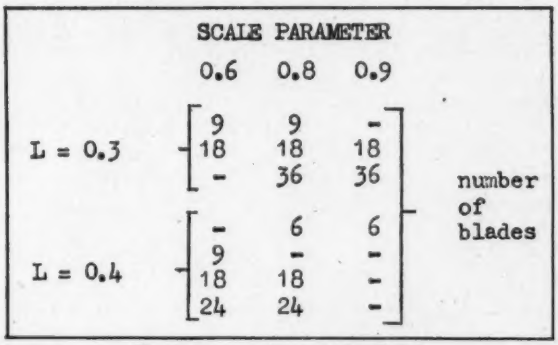


Fig. 3. Improved layout for Fig. 2.

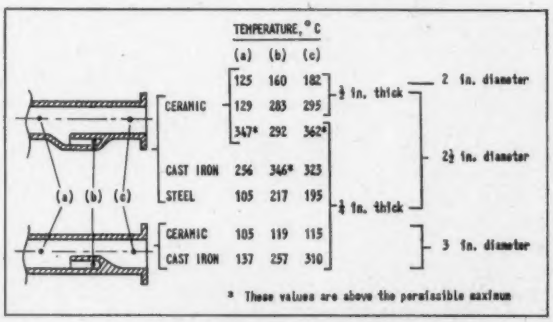


Fig. 4. Further example of good table layout.

These headings are then given at their appropriate places in the text, and normally occur more frequently than once per page.

The system of headings must be logical, or it will be actually misleading. In particular, sub-sections must add up to the section headings which purport to comprise them, and all the material which ought to appear under any particular heading must do so. When the logical system of headings requires several very short sections, the text may be interrupted in a manner which would be objectionable to the stylist; but stick to your system. Organisation is All.

As to the sequence of the information, requirements vary

widely, but the imaginary list of headings shown above is a reasonable basis at least for one common type of report. The Introduction and Conclusion are commonly the worst written parts, and the most important. The Introduction must be written very deliberately to set the scene for the expected reader. The assumption that what one knows is common knowledge must be avoided. The Conclusions must distinguish between conclusions drawn and the evidence from which they are drawn. These two sections, one explaining the need for the work and its objects, and the other its lessons, must be compatible. They must also be short, or they will not be read or (what is often worse) they may be half read.

Writing Style

When writing the parts of the text that must be just written conventionally, the only inevitable difficulty is in ensuring that the points are made in their best order. The other difficulties chiefly arise from over-complication.

The raw data for technical authorship consist of a number of discrete concepts which may be shuffled into a logical order. Consider the following:

The rig was first run for 6 hours,
The speed was 7,000 r.p.m.,
The temperature rose to 80 deg. C. within 10 minutes, and stayed there,
Then the rig was stopped, regreased and started again,
After 43 minutes the temperature began to rise sharply,
When it had risen to 106 deg. C., the rig was stopped.

Written like this, it risks giving an impression of simple-mindedness, but it is entirely in rendering such plain material into more sophisticated form that we run into trouble. We write, perhaps:

After running for 6 hours at 7,000 r.p.m. and 80 deg. C., the rig was stopped, regreased and restarted. However, 43 minutes after the commencement of this second phase of the test programme the running temperature began to rise rapidly. The rig was therefore stopped, the temperature having reached 106 deg. C.

This is not a specimen of poor writing, but if the item has become smoother, it has also become harder to extract any one particular figure from. As so often happens, quite irrelevant information, that about the second phase of the test programme, has been introduced merely to get the author out of a slight stylistic difficulty; a subsidiary piece of information, that it took ten minutes to reach equilibrium temperature, was omitted for the same reason.

To correct these faults, and a certain pompousness:

The rig was run for 6 hours at 7,000 r.p.m., the temperature rising to 80 deg. C. within 10 minutes, and remaining so. It was then stopped, regreased and restarted. After 43 minutes the temperature began to rise sharply, and when it had reached 106 deg. C. the rig was stopped.

I still have a sneaking regard for the too-simple first arrangement, however. The information positively jumps out at you.

DIMENSIONAL ASPECTS OF INVESTMENT CASTING

THE object of a recent paper* was to discuss the dimensional aspects of lost wax investment castings for the benefit of those who are entitled to know why the process, which is often claimed to be accurate to ±0·005 in. per inch, regularly fails to achieve this tolerance.

Obviously, the range of tolerance laid down by the customer's drawing, and to which the investment founder endeavours to work, should never be tighter than is necessary for the correct functioning of the component. A high percentage of drawings submitted to the investment founder have tolerances of the order of ±0·003 in. or even ±0·001 in., which are normal for production by conventional machining operations but are not always functionally necessary.

When a complete batch of castings is measured on any dimension the results invariably show a "scatter", which implies that a series of factors have influenced production in such a way as to alter the dimensions and operate at random. Process variables are responsible for a fairly well defined form of scatter about the mean dimension and an average casting dimension is usually about 2 per cent smaller than the die-cavity dimension. This is due to wax contraction, shrinkage of the casting from the molten state to room temperature, mould cavity expansion due to the expansion of the wax, mould shrinkage on drying out its liquid binder, and mould expansion due to the high-temperature firing (approx 1,000 deg. C.).

In the early days of the investment foundry industry the normal practice was to put through samples for dimensional check and thus arrive at a percentage contraction figure for future use. As a result, various investment foundries have had their own standards. It is essential for the founder to make and check dimensionally a sufficient number of samples to establish reasonably accurately the mean or average dimensions typical of production of each component. These results enable adjustment of the die dimensions to be made where necessary; to give the maximum acceptable yield "as cast" to minimise the percentage of castings outside the acceptance range; and to minimise the amount of finishing work where fettling to gauge limits is involved.

Detailed analysis has shown certain grounds for suggesting that on the smallest dimensions tolerances better than ±0·005 in. can often be obtained; thus where no adverse factors exist, the investment founder might reasonably offer to supply "as cast" dimensions as follows:

0·000 in. to 0·25 in. ±0·003 in.
0·25 in. to 0·50 in ±0·004 in.

The foregoing comments centre on the problems involved in achieving "as cast" dimensions, but every casting must have some area or areas where it must be separated from the ingates or feeder-head. Where these areas are non-critical, or where a machining allowance has been incorporated, only semi-skilled hand finishing is called for. Where, however, the tolerances required are of the order of ±0·005 in. or even closer, or where the customer is unable to accommodate such finishing, the investment founder is obliged to extend his activities outside the scope of foundry practice and demand a different class of labour.

It is well known that some investment foundries, e.g., those tied to aircraft firms, are integrated with engineering workshops, and it is natural for them to approach production of components from the general standpoint of engineering as distinct from foundry products. As such, it is relatively easy for them to consider the overall cost of the completed component, rather than the piece cost of the casting.

For the designer and the buyer of investment castings as "bought-out goods" from an investment foundry, the position is rather different. The cost of such dressing operations and machining to fine limits adds considerably to the cost of the component and is usually completely out of balance to the actual cost of producing the casting.

It is not surprising, therefore, with the different practices employed by investment foundries, that the buyer and designer is often at a loss to establish what is to be expected as an investment casting.

* "Dimensional Aspects of Lost Wax Investment Casting" by R. Taylor and N. Mason. Second Annual Conference, British Investment Casters' Technical Association.

OVERSEAS NEWSLETTER

A monthly digest of reports from our foreign correspondents of other countries' current achievements in research and development work

High-temperature Thermocouples

From work carried out in the U.S.S.R. it has been established that a number of alloys of high-temperature semiconductor compounds of the boron carbide or chromium silicide type with compounds such as carbides and borides exhibit high E.M.F. values and a linear dependence in the temperature range from 300-400 to 2,000-2,200 deg. C. These compounds and alloys also have a high resistance to aggressive media.

A high-temperature thermocouple for temperatures up to 1,800 deg. C. has been developed in the Institute of Powder Metallurgy, Cermets and Special Alloys, Academy of Sciences, U.S.S.R., which consists of molybdenum disilicide and graphite treated with boron. It develops a thermal electromotive force reaching forty microvolts per degree, which is four times higher than the thermal E.M.F. of the platinum/platinum-rhodium couple, and because of the high thermal E.M.F. developed by the new thermocouple it is possible to make more precise measurements. Furthermore, it has the advantages of low cost and simplicity through production by power metallurgy methods from readily available materials.

When the thermocouple is used for measuring the temperature in aluminium electrolysis cells it is protected by a sheath of silicon nitride. It was found that silicon nitride has an excellent resistance to the action of molten metals and is therefore a suitable material for protective sheaths. Silicon nitride does not, however, form good junctions with boron-treated graphite, and for this reason cannot be used as an outer tubular electrode in thermocouples of this type. When protected by a sheath of titanium nitride, the thermocouple can be kept in liquid steel for three hours. At present, sheaths made of zirconium boride or titanium boride, to which molybdenum has been added, can remain for thirty minutes in the molten iron of a blast furnace.

Still higher temperatures must be measured in connection with the industrial production of hard alloys, and for this type of application Ukrainian scientists have developed a semiconductor thermocouple which can be used at 2,000-2,300 deg. C. The outer tube for this is made of titanium carbide and the core of boron carbide, the thermocouple having a thermal E.M.F. of forty-five microvolts per degree. Thermocouples of this type can be used only in a chemically inactive medium, such as vacuum, inert gas or hydrogen, which is the normal protective atmosphere used in a furnace in which hard alloys are produced.

At the same Institute a thermocouple has been developed which consists of boron carbide and silicon carbide and which develops an unusually high thermal E.M.F. up to 600 microvolts per degree. A number of thermocouples developed consisted of graphite treated with boron and carbides, or borides of titanium, zirconium, and other refractory metals, and they exhibited linear scale E.M.F. characteristics. On the basis of the results obtained, it was concluded that there are no practical limitations to the selection of suitable materials and construction for high-temperature semiconductor thermocouples with sufficient E.M.F., adequate sensitivity, and sufficient stability for any applications.

Photoelectric Follow-up

The conventional reed contact in the follow-up system of measuring devices with pointers requires a pointer torque which is not available in sensitive mechanical and electrical measuring appliances; moreover, the reading accuracy is impaired and the measuring circuit adversely affected. One solution to overcome these disadvantages has been the introduction of the h.f. oscillation circuit, the coupling of which is interrupted by a "vane" on the pointer, resulting in a relay with high-voltage contacts being actuated. This system is costly and space-consuming and a better solution is in the employment of small selenium photocells, in which, however, the use of movable markers is limited to circuit-closing for maximum and minimum values.

More recently, preference has been given to photo-resistance cells over selenium cells; they can now be made small and sensitive enough with an adequate accuracy tolerance. An interesting design embodying this system is the Pantam Measuring Contactor. In this device contact-making over the whole range of the scale is completely free of feedback, so that the true reading is never affected.

Fig. 1 shows diagrammatically the action of the instrument. The moving component carries a circular screen (1), whose shadow image (4), is projected by the light source (2), by means of a mirror lens (3). As the pointer (5) moves, the screens (6), attached to it, cover the inlet slit of one or the other photo-resistance (7). The resulting increase in the latter's resistance is used for controlling a cold-cathode thyratron or similar supplementary switching circuit.

With the pointer passing the contact point and beyond, the inlet slit of the photo-resistance continues to be blocked, since the circular screen (1) and its shadow move with the pointer.

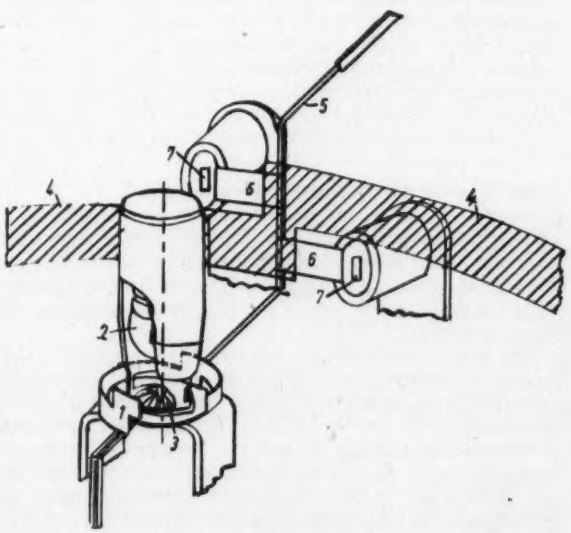


Fig. 1. Diagrammatic view showing operation of Pantam Measuring Contactor.

Microsecond Electromechanical Switch

A very fast electromechanical switch called the "ferreed" has been developed by Bell Telephone Laboratories, and utilises a new technique for actuation which is compatible in speed with electronic circuits.

The ferreed may find use as an interconnecting element in telephone switching networks and other applications where advantage may be taken of metallic contacts controllable by current pulses of a few microseconds duration.

The ferreed combines the rapid switching of bistable magnetic material with metallic contacts for output indications that persist as long as desired without further application of power. In several models of the device, a cobalt ferrite has been used as the magnetic material and a glass-sealed magnetic reed switch for the output contacts.

In operation, the magnetic material is switched by a magneto-motive force applied, typically, as a five-ampere current pulse in a thirty-turn winding. Control pulses as short as five microseconds will switch the magnetic material, resulting in the passage of magnetic flux through the movable members of the reed switch. Actual closure of the contacts is delayed by inertia of the reeds for several hundred microseconds.

Release of the contacts is brought about by cancellation of the magnetic flux through the reeds, as the result of another five-microsecond switching operation. Opening of the contacts requires less time than the closing operation.

Several new magnetic materials have been synthesised for use in developmental models of the ferreed, and among these are ferrites exhibiting characteristics midway between permanent magnets and computer memory materials and ferrite suspensions in plastics.

Adhesive for Concrete and Steel

An adhesive with a polyester base has been announced in the Netherlands by Edilon N.V. The adhesive is called Edilon P5001, and is said to be suitable for joining concrete or steel surfaces. The material is supplied in the form of components which are mixed in equal parts to the consistency of priming putty. All traces of rust or paint on steel surfaces must be removed, and the mixture is then spread over the two mating surfaces. The hardening period is 20 min. at 20 deg. C., and the joint may be loaded two hours later.

Test results indicated that the resistance to shearing of small-diameter bars cemented in concrete was 140-350 p.s.i., while the shearing strength of a joint between two concrete surfaces was in excess of 200 p.s.i. The shearing strength of a joint between two steel surfaces was given as 150-410 p.s.i. Tensile and transverse strengths of Edilon P5001 are given as 500 p.s.i. and 500-570 p.s.i. respectively. The resistance of the cement to vibration and impact is evidently good and it has a shrinkage on setting of about 1 per cent. Compressive strength of the cement is about 14,200 p.s.i.

Heat Pump Air Conditioners

Heat pumps serve to "pump" heat from a certain level of temperature to a higher one (heating) or to a lower one (cooling). Their application has in the past been limited to the heat-conditioning of large plants, using the heat capacity of rivers or lakes, but this is a costly process not practical for small plants.

The heat pump principle has now been applied to the heating of relatively small premises, using the capacity of atmospheric air instead of that of water. The heat pump developed by W. Hausler & Co. of Zürich uses a reversible freon cycle; in summer the freon is compressed and flows into a condenser where it is liquefied, giving off heat into the surrounding air. It then reaches an evaporator where it evaporates, drawing heat from the atmosphere of the conditioned room. In winter the reverse process occurs, the evaporator acting as a condenser and vice versa, so that heat withdrawn from the outside air (by cooling) is transferred to the inside air. In effect, the pump automatically assures several functions; cooling and dehumidifying in hot weather, raising indoor ambients by 3-5 deg. C. during the transition period and, finally, in cold weather, raising the indoor temperature by 1-3 deg. C. to supplement the action of the central heating, and, at the same time, assuring adequate air moisture and purity.

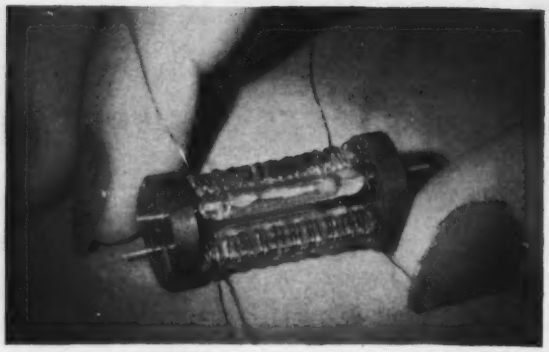


Fig. 2. Two-branch ferreed electromechanical fast switch.

The cost of the installation is slightly higher than for a conventional water-cooled plant, but the slight difference in price is more than offset by the low running costs and the fact that cooling water is not required.

New Approach to Metal Coatings

A metal coating process based on super-fluidity is being developed by Fuji Precision Co. and Nippon Gaishi (Porcelain Insulators) Co.

Super-fluidity is a phenomenon which, until the present, has been observed only in liquid helium, and it is the ability, when super-cooled, to "wet" almost any surface due to a sudden lessening in the energy of molecular attraction. The effect on substances with larger molecules than helium and higher viscosities is small and difficult to detect, but when substances are suddenly super-cooled near the freezing point a change can be detected in the specific heat of many metals as they change from liquid to solid state.

Dr. Takahashi, Japanese scientist of Chiba Institute of Technology, reasoned that if a droplet of molten metal from an electric spark was dropped on to the surface to be plated and became super-cooled as it touched the surface, super-fluidity should occur, and the drop should instantaneously spread over the surface. The only requirement for plating one material on to another is a clean plating surface, and the maintenance of a proper temperature differential between the molten droplet and the plating surface in order to cause super-cooling.

Plastic Hot Panel

An electric heating appliance developed by the Leningrad Research Institute for Water and Sanitary Engineering consists of a plate 3-4 mm. thick, at a temperature not exceeding 50 deg. C.; an inner layer carrying the current is made from a specially prepared mixture of synthetic rubber and acetylene black enclosed in an insulating rubber sheath. The external faces can be given any desired colour, and the plate can be used as wall cladding. Temperature control is achieved by connecting one or more plates, and four 1 sq. m. plates are sufficient to heat a 20 sq. m. room with a total power of 1 kW.

It has been computed that, when mass produced, these panels would be more economical for space heating than steam heating from a central plant.

STAINLESS STEELS

Engineering Materials and Design
DATA SHEET No. 40

Nominal Compositions

1	C 0·12 Cr 18·5 Ni 8·5	2	C 0·06 Cr 18·5 Ni 8·5	3	C 0·12 Cr 18·5 Ni 8·5 Ti 0·5	4	C 0·07 Cr 18·5 Ni 13·0 Mo 3·0	5	C 0·12 Cr 12·5 Ni 12·5
6	C 0·10 Cr 18·5 Ni 8·5 Cb 1·0	7	C 0·04 Cr 17·5 Ni 12·0 Mo 2·75 Cb 0·75	8	C 0·12 Cr 13·0 Mn 0·30	9	C 0·20 Cr 13·0 Mn 0·30	10	C 0·32 Cr 13·0 Mn 0·30
11	C 0·20 Cr 18·0 Ni 1·25 Mn 1·0 max.								

Equivalent Specifications

1. B.S.970: En.58A.
2. B.S.970: En.58E.
3. DTD 571, DTD 171A, DTD 176B, B.S.970: En.58B.
4. B.S.970: En.58J.
5. B.S.970: En.58D.
6. B.S.970: En.58F.
7. B.S.1503-845, grade B. B.S.1506-845, grade B.
8. B.S.: S.61, B.S.970: En56A.
9. B.S.: S.62, B.S.970: En.56C.
10. B.S.970: En.56D.
11. B.S.: S.80, B.S.970: En.57.

PHYSICAL PROPERTIES

	Specific Gravity	Thermal Conductivity c.g.s. units (at 20°C.)	Electrical Resistivity microhm./c.c. (at 20°C.)	Coeff. Thermal Expansion 0-200°C.	Coeff. Thermal Expansion 0-450°C.	Magnetic Properties
1	7·93	0·036	72	0·0000170	0·0000178	Non-magnetic
2	7.93	0.038	70	0.0000170	—	Non-magnetic
3	7·90	0·038	73	0·0000175	0·0000180	Non-magnetic
4	7·96	0·039	72	0·0000165	—	Non-magnetic
5	8·01	0·037	70	0·0000185	—	Non-magnetic
6	7·93	0·038	72	0·0000175	0·0000180	Non-magnetic
7	7·96	0·039	72	0·0000165	—	Non-magnetic
8	7·73	0·059	56	0·000011	0·000012	Magnetic
9	7·75	0·058	57	0·000011	0·000012	Magnetic
10	7·74	0·050	53	0·000011	—	Magnetic
11	7·70	0·045	72	0·000011	0·000012	Magnetic

MECHANICAL PROPERTIES

	Yield Pt. t.s.i.	Maximum Stress t.s.i.	Elong. %	Reduction of Area %	Izod Impact ft. lb.	Brinell Hardness
1	15–18	35–45	40–60	45–60	95–105	160–190
2	15–18	35–45	40–60	45–60	95–105	160–190
3	15–18	35–45	40–60	45–60	95–105	160–190
4	15–18	35–45	40–60	45–60	75–85	160–190
5	13–17	32–40	40–60	45–60	95–105	130–160
6	15–18	35–45	40–60	45–60	95–105	160–190
7	20–30	35–45	40–60	60–75	95–105	170–200
8 (a)	25	38	35	75	98	175
(b)	17	30	38	77	100	140
9 (c)	40	45	30	65	35	200
10 (d)	85	95	15	35	10	450
11 (e)	48	58	20	45	40	270
(f)	36	50	14	—	—	225

(a) OQ 950°C. Temp. 700°C.
(b) Annealed 750°C.
(c) OQ 950°C.
(d) OQ 950°C. Temp. 180°C.
(e) OQ 950°C. Temp. 600°C.
(f) Annealed.

	Max. Service Temp., °C.	Welding Properties
1	300	Good, but requires heat treatment after welding.
2	300	Good, but not recommended for service in highly corrosive conditions.
3	800	Good. No subsequent treatment required.
4	300	Good. Heat treatment after welding desirable where practicable.
5	300	Good, but requires heat treatment after welding.
6	800	Good. No subsequent heat treatment required.
7	800	Good. No subsequent heat treatment required.
8	750	Fair. Welds tend to be brittle. Requires heat treatment after welding.
9	750	Poor. Welds tend to be brittle. Requires heat treatment after welding.
10	—	Poor. Welds tend to be brittle. Requires heat treatment after welding.
11	650	Poor. Welds brittle. Little response to heat treatment.

HEAT TREATMENT

	Hot Working, °C. Start	Hot Working, °C. Finish	Softening °C.	Hardening °C.	Tempering °C.
1	1,200	900	1,050-1,100 (cool quickly)		—
2	1,200	900	,,		—
3	1,200	900	,,		—
4	1,200	900	,,	Not hardenable except by cold working	—
5	1,200	900	1,050 (cool quickly)		—
6	1,200	900	1,050-1,100 (cool quickly)		—
7	1,200	900	,,		—
8	1,150	950	AC 750	OQ, WQ or AC 950-1,000	600-750
9	1,150	950	AC 750		600-750
10	1,150	950	AC 750 or slow cool 850-900 AC 650	OQ or AC 950-1,000	150-180
11	1,150	950			550-650

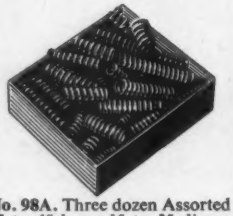
Data by courtesy Dr. E. Gregory, Edgar Allen & Co. Ltd.

THAT *Experimental Spring* YOU WANT IS WAITING FOR YOU IN THIS BOX ...

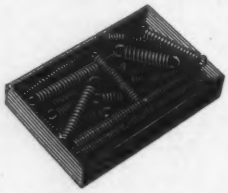
No. 1217. One gross Assorted Springs. A complete Garage Service Kit. 42/- each.

If not, try another box in the Terry Assorted Springs range

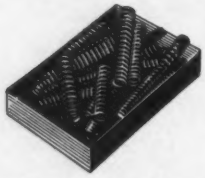
No. 1200. Three dozen Assorted Light Expansion Springs, suitable for carburettor control, etc. **13/6.**



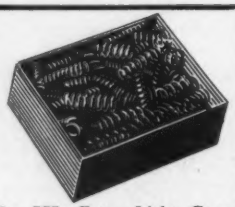
No. 98A. Three dozen Assorted 1″ to 4″ long, ¼″ to ⅜″ diam., 19G to 15G. **5/6.**



No. 753. Three dozen Assorted Light Expansion ¼″ to ½″ diam., 2″ to 6″ long, 22 to 18 S.W.G. **10/6.**



No. 760. Three dozen Assorted Light Compression Springs. 1″ to 4″ long, 22 to 18 S.W.G., ¼″ to ½″ diam. **6/6.**



No. 757. Extra Light Compression, 1 gross Assorted, ¼″ to ⅜″ diam., ½″ to 2½″ long, 27 to 19 S.W.G. **15/-.**

No. 758. Fine Expansion Springs. 1 gross Assorted ¼″ to ⅜″ diam., ½″ to 2″ long, 27 to 20 S.W.G. **15/-.**

We know *exactly* how difficult it is to find springs for experimental work . . . we've been making quality springs for over 100 years. So, we confidently offer you our excellent range of small boxed assortments which covers a very wide range. We can only show a *few* boxes. Send us a p.c. for our full list. If ever you are stuck with a spring problem let our Research Department put their long experience at your disposal.

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HT30

SELF-TAPPING SCREWS

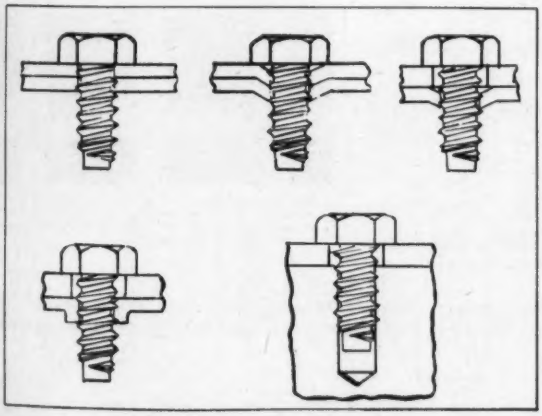
In the tables, hole sizes are given in inches.

Figures in parentheses refer to drill sizes.

HEXAGON HEAD—TYPE Z, BLUNT POINT.

Dia. of Screw	Sheet Thickness	Sheet Steel: Pierced Hole	Sheet Steel: Drilled or Punched	Light Alloy: Pierced Hole	Light Alloy: Drilled or Punched	Non-ferrous Castings	Plastics
No. 6 (.137)	.022	.111	.104(37)	.111	.104(37)	.128(30)	.120(31)
	.028	.111	,,	.111	,,	,,	,,
	.036	.111	,,	.111	,,	,,	,,
	.048	—	,,	.111	,,	,,	,,
	.064	—	.110(35)	—	.106(36)	,,	,,
	.080	—	.113(33)	—	.110(35)	,,	,,
	.104	—	.120(31)	—	.111(34)	,,	,,
	.128	—	,,	—	.113(33)	,,	,,
	.144	—	,,	—	.113(33)	,,	,,
	.160	—	.128(30)	—	.116(32)	,,	,,
	$\frac{1}{16}$"	—	—	—	.120(31)	,,	,,
No. 8 (.163)	.022	.136	.116(32)	.136	—	.152(24)	.147(26)
	.028	.136	,,	.136	.116(32)	,,	,,
	.036	.136	,,	.136	.116(32)	,,	,,
	.048	.136	.120(31)	.136	.120(31)	,,	,,
	.064	—	.128(30)	—	.128(30)	,,	,,
	.080	—	.136(29)	—	.136(28)	,,	,,
	.104	—	.140(28)	—	.140(28)	,,	,,
	.128	—	.144(27)	—	.144(27)	,,	,,
	.144	—	.144(27)	—	.144(27)	,,	,,
	.160	—	.149(25)	—	.149(25)	,,	,,
	$\frac{3}{16}$"	—	—	—	.152(25)	,,	,,
No. 10 (.186)	.022	.157	.144(27)	.157	—	.177(16)	.166(19)
	.028	.157	,,	,,	—	,,	,,
	.036	.157	,,	,,	.144(27)	,,	,,
	.048	.157	,,	,,	.144(27)	,,	,,
	.064	—	.149(25)	.144	—	,,	,,
	.080	—	.152(24)	.147(26)	—	,,	,,
	.104	—	.157(22)	.147(26)	—	,,	,,
	.128	—	.161(20)	.154(23)	—	,,	,,
	.144	—	.161(20)	.154(23)	—	,,	,,
	.160	—	.169(18)	.159(21)	—	,,	,,
	$\frac{3}{16}$"	—	—	.166(19)	—	,,	,,
No. 14 (.243)	.028	.209	.185(13)	—	—	.234($\frac{15}{64}$")	.288(I)
	.036	.209	.185(13)	—	—	,,	,,
	.048	.209	.191(11)	—	—	,,	,,
	.064	—	.199(8)	—	.199(8)	,,	,,
	.080	—	.204(6)	—	.201(7)	,,	,,
	.104	—	.209(4)	—	.204(6)	,,	,,
	.128	—	.228(1)	—	.209(4)	,,	,,
	.144	—	.228(1)	—	.209(4)	,,	,,
	.160	—	.234($\frac{15}{64}$")	—	.213(3)	,,	,,
	.192	—	.234($\frac{15}{64}$")	—	.221(2)	,,	,,
	$\frac{1}{4}$"	—	—	—	.213(3)	,,	,,
	$\frac{3}{16}$"	—	—	—	.228(1)	,,	,,

Typical combinations of thicknesses.



SLOTTED HEAD—TYPE A, GIMLET POINT.

(Also available with Phillips recess.)

Dia. of Screw	Sheet Thickness	Sheet Steel: Pierced Hole	Sheet Steel: Drilled or Punched	Light Alloy: Pierced Hole	Light Alloy: Drilled or Punched	Resin-bonded Plywood	Ebony, Asbestos etc.
No. 4 (.112)	.015	—	.086(44)	—	.086(44)	.098(44)	.093(42)
	.018	—	.086(44)	—	.086(44)	,,	,,
	.022	.098	.093(42)	.096	.089(43)	,,	,,
	.028	,,	,,	.096	.093(42)	,,	,,
	.036	,,	,,	.096	.096(41)	,,	,,
No. 6 (.138)	.015	—	.099(39)	—	.099(39)	.110(35)	.106(36)
	.018	—	,,	—	,,	,,	,,
	.022	.111	,,	.110	,,	,,	,,
	.028	,,	.101(38)	,,	.101(38)	,,	,,
	.036	,,	.106(36)	,,	.104(37)	,,	,,
No. 8 (.165)	.018	.136	.113(33)	—	.113(33)	.140(28)	.136(29)
	.022	,,	,,	.136	,,	,,	,,
	.028	,,	.116(32)	,,	.116(32)	,,	,,
	.036	,,	.120(31)	,,	.120(31)	,,	,,
	.048	,,	.128(30)	,,	.125($\frac{1}{8}$)	,,	,,
No. 10 (.191)	.018	.157	.128(30)	—	.128(30)	.169(18)	161(20)
	.022	,,	,,	.154	,,	,,	,,
	.028	,,	,,	,,	,,	,,	,,
	.036	,,	.136(29)	,,	.136(29)	,,	,,
	.048	,,	.149(25)	,,	,,	,,	,,
No. 12 (.218)	.022	—	.147(26)	—	.147(26)	.189(12)	.185(13)
	.028	.185	.149(25)	.182	.149(25)	,,	,,
	.036	,,	.152(24)	,,	.152(24)	,,	,,
	.048	,,	.157(22)	,,	.157(22)	,,	,,
No. 14 (.251)	.022	—	.180(15)	—	.180(15)	.228 (I)	.213(3)
	.028	.209	.189(12)	.205	.187($\frac{3}{16}$")	,,	,,
	.036	,,	.191(11)	,,	.189(12)	,,	,,
	.048	,,	.196(9)	,,	.193(10)	,,	,,

SLOTTED HEAD—TYPE Y, THREAD CUTTING.

(Also available with Phillips recess.)

Dia. of Screw	Sheet Thickness	Steel	Cast Iron	Plastics
No. 4 (.112)	.064	.099(39)	.104(37)	.099(39)
	.128	.104(37)	,,	,,
	.250	,,	,,	,,
	.375	,,	,,	,,
No. 6 (.133)	.064	.120(31)	.128(30)	.120(31)
	.128	.128(30)	,,	,,
	.250	,,	,,	,,
	.375	,,	,,	,,
No. 8 (.163)	.064	.144(27)	.152(24)	.140(28)
	.128	.152(24)	,,	,,
	.250	.154(23)	,,	,,
	.375	,,	,,	,,
No. 10 (.186)	.064	.166(19)	.177(16)	.173(16)
	.128	.177(16)	,,	,,
	.250	,,	,,	,,
	.375	.182(14)	,,	,,
No. 12 (.212)	.064	.191(11)	.196(9)	.193(10)
	.128	.193(10)	,,	,,
	.250	.193(10)	,,	,,
	.375	.196(9)	,,	,,

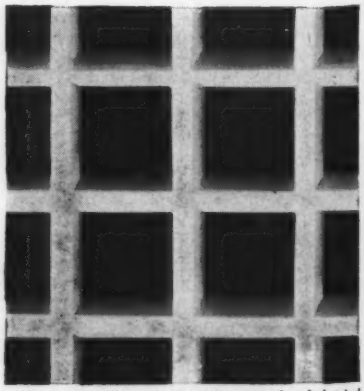
†Tapped holes should be chamfered and a clearance hole made in part to be fixed.

for heat resistance

special "thin-flash" type for grille moulding

Beetle D.M.C. is the material used for the grille of the Morphy-Richards Fan Heater because it offers high heat resistance and good appearance. The use of D.M.C. posed a flash-removal problem in relation to the many apertures, as the moulders, Crystalate (Mouldings) Ltd., specified a very thin flash line. Accordingly, B.I.P. Chemicals Ltd. developed a special type of material (D.M.C. L.1834) which, in combination with a tool made to close limits, ensures a consistently thin and easily removed flash.

Beetle D.M.C. combines heat resistance with strength, dimensional stability and excellent insulation properties. The development of a special type for a single application typifies the extent of B.I.P. services in relation to individual problems and requirements.



Heat resistance, dimensional stability, strength and electrical insulation properties are among the features making D.M.C. the ideal material for this grille. Moulding by Crystalate (Mouldings) Ltd, Tonbridge, Kent.

BEETLE*

Polyester **d**ough **m**oulding **c**ompound

B.I.P. Chemicals Limited, Oldbury, Birmingham. Phone BROadwell 2061
London Office: Haymarket House, 28 Haymarket, S.W.1. Phone TRAfalgar 3121

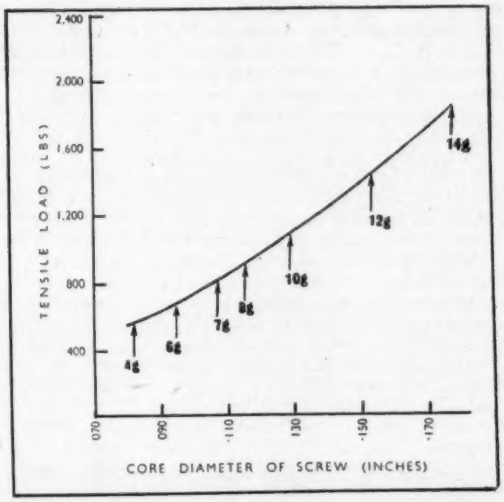
(Cont. from page 437)

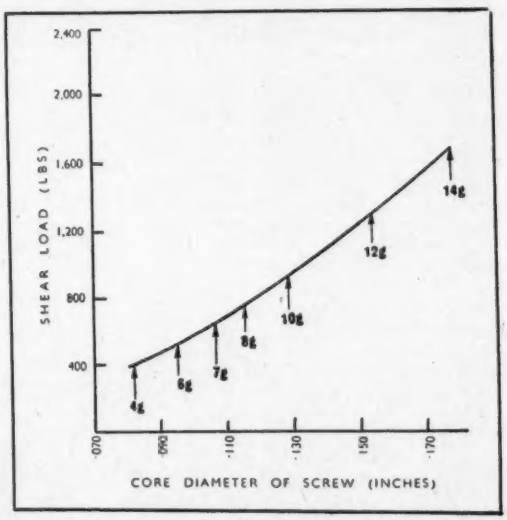
SLOTTED HEAD—TYPE Z, BLUNT POINT.

(Also available with Phillips recess.)

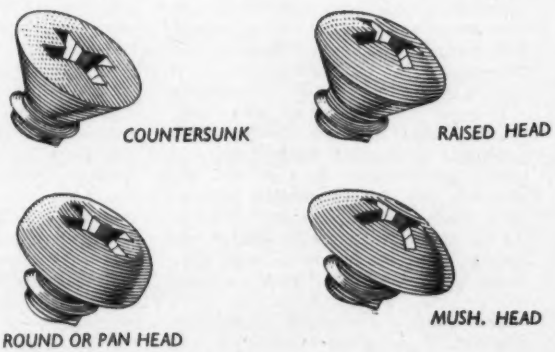
Dia. of Screw	Sheet Thickness	Sheet Steel		Light Alloy		Non-ferrous Castings	Plastics
		Pierced Hole	Drilled or Punched	Pierced Hole	Drilled or Punched		
No. 2	.015	—	.063(52)	—	—	.078(47)	.078(47)
(.086)	.018	—	.063(52)	—	—	,,	,,
	.022	—	.067(51)	—	.063(52)	,,	,,
	.028	—	.070(50)	—	,,	,,	,,
	.036	—	.073(49)	—	,,	,,	,,
	.048	—	.073(49)	—	.067(51)	,,	,,
	.064	—	.076(48)	—	.070(50)	,,	,,
No. 4	.015	.086	.086(44)	—	—	.104(37)	.099(39)
(.112)	.018	.086	.086(44)	—	—	,,	,,
	.022	.098	.089(43)	.086	—	,,	,,
	.028	.098	.093(42)	.086	.086(44)	,,	,,
	.036	.098	.093(42)	.086	,,	,,	,,
	.048	—	.096(41)	.086	,,	,,	,,
	.064	—	.099(39)	—	.089(43)	,,	,,
	.080	—	.101(38)	—	.089(43)	,,	,,
	.104	—	—	—	.093(42)	,,	,,
No. 6	.015	.111	.104(37)	—	—	.128(30)	.128(30)
(.137)	.018	.111	.104(37)	—	—	,,	,,
	.022	.111	.106(36)	.111	—	,,	,,
	.028	.111	.106(36)	.111	.104(37)	,,	,,
	.036	.111	.110(35)	.111	,,	,,	,,
	.048	—	.111(34)	.111	,,	,,	,,
	.064	—	.116(32)	—	.106(36)	,,	,,
	.080	—	.120(31)	—	.110(35)	,,	,,
	.104	—	.128(30)	—	.111(34)	,,	,,
	.128-.250	—	—	—	.120(31)	,,	,,
No. 8	.018	.136	—	—	—	.152(24)	.149(25)
(.163)	.022	.136	.116(32)	.136	—	,,	,,
	.028	.136	.120(31)	.136	.116(32)	,,	,,
	.036	.136	.120(31)	.136	.120(31)	,,	,,
	.048	.136	.128(30)	.136	.128(30)	,,	,,
	.064	—	.136(29)	—	.136(29)	,,	,,
	.080	—	.140(28)	—	.140(28)	,,	,,
	.104	—	.149(25)	—	.147(26)	,,	,,
	.128	—	.149(25)	—	.147(26)	,,	,,
	.144	—	.152(24)	—	.149(25)	,,	,,
	.160-.372	—	—	—	.152(24)	,,	,,
No. 10	.018	.157	.144(27)	—	—	.177(16)	.177(16)
(.186)	.022	,,	,,	.157	—	,,	,,
	.028	,,	,,	.157	—	,,	,,
	.036	,,	.147(26)	.157	.144(27)	,,	,,
	.048	.158	.152(24)	.157	,,	,,	,,
	.064	—	.152(24)	—	,,	,,	,,
	.080	—	.157(22)	—	.147(26)	,,	,,
	.104	—	.161(20)	—	.147(26)	,,	,,
	.128	—	.169(18)	—	.154(23)	,,	,,
	.144	—	.173(17)	—	.154(23)	,,	,,
	.160	—	.173(17)	—	.159(21)	,,	,,
	.192-.372	—	—	—	.166(19)	,,	,,
No. 12	.022	.185	.166(19)	—	—	.199(8)	.199(8)
(.212)	.028	.185	,,	—	—	,,	,,
	.036	.185	,,	—	—	,,	,,
	.048	.185	.169(18)	—	.161(20)	,,	,,
	.064	—	.177(16)	—	.166(19)	,,	,,
	.080	—	.182(14)	—	.173(17)	,,	,,
	.104	—	.185(13)	—	.180(15)	,,	,,
	.128	—	.196(9)	—	.182(14)	,,	,,
	.144	—	.196(9)	—	.182(14)	,,	,,
	.160	—	.201(7)	—	.189(12)	,,	,,
	.192-.372	—	—	—	.196(9)	,,	,,
No. 14	.028	.209	.185(13)	—	—		
(.243)	.036	.209	.185(13)	—	—		
	.048	.209	.191(11)	—	—		
	.064	—	.199(8)	—	.199(8)		
	.080	—	.204(6)	—	.201(7)	.234($\frac{15}{64}$")	.234($\frac{15}{64}$")
	.104	—	.209(4)	—	.204(6)		
	.128	—	.228(1)	—	.209(4)		
	.144	—	.228(1)	—	.209(4)		
	.160	—	.234($\frac{15}{64}$")	—	.213(3)		
	.192	—	,,	—	.221(2)		
	$\frac{1}{4}$-.372	—	,,	—	— .228(1)		

Data from Guest Keen & Nettlefolds (Midlands) Ltd. and Linread Ltd.





TENSILE AND SHEAR STRENGTHS OF TYPE Z ROUND-HEAD SCREWS.



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THIS book covers the international symposium at the eighth annual meeting of the International Organisation for Standardisation of Plastics, held in Washington, D.C., in 1958. It is divided into four sections. Part 1 deals with standardisation in various countries, explaining their origin, sources of funds, status of standards and hall-marks, etc. Part 2 covers engineering properties with chapters on the fundamentals of the mechanical properties of plastics, anisotropic effects and the most suitable shapes to be taken for conducting shear strengths.

Part 3 deals with thermal properties, and relevant testing methods are explained for thermosetting and thermoplastic moulding compounds and the Vicat softening point. The rheology of polymer melts and the transition phenomena in the study of impact strength of plastics is also dealt with in this section. Part 4 is devoted to molecular characterisation. *F. Smith*

Progress in Dielectrics. Vol. 2. *Edited by J. B. Birks and J. H. Schulman.* (*Heywood, 15s.*)

The present issue is a worthy successor to Volume 1. The six topics dealt with are: theory of polarisation and absorption; properties of polymeric systems; irradiated polymers; properties of glass; high-permittivity ceramics; and artificial dielectrics.

It is difficult in a short space to comment on each section individually. Collectively, the articles are well written and of considerable current interest. Each section is self-contained and comprises a reasonably comprehensive review of the subject, including recent progress, and contains many useful references. Although the subjects are diverse, everyone associated with dielectrics should find something of interest, and particularly the theoretical emphasis will be welcomed by the physicist engaged in dielectric research. *E.A.W.*

Fracture. *By B. L. Averback, D. K. Felbeck, G. T. Hahn and D. A. Thomas.* (*Chapman & Hall, 140s.*)

Papers read at the recent conference on the atomic mechanisms of fracture in materials are now presented in this book, together with discussions and appropriate references. The majority of the papers are devoted to the study of metals, but several discuss fracture in ceramics and polymers.

In metal physics there has been a long-standing need to relate the theoretical approach to fracture mechanisms with actual experimental findings and this obviously has been successfully achieved as a result of this conference. Further, the current interest in brittle fracture and fatigue failure conditions is clearly illustrated by the number of papers devoted solely to these aspects.

The book is well prepared, having many excellent diagrams and illustrations, and is intended for workers conversant with current physical metallurgy methods. *R. Hazzard*

Pneumatics for Industry. *By F. X. Kay.* (*Machinery Publishing Co., 18s. 6d.*)

This book sets out to describe the principles underlying the industrial use of pneumatics and is to be particularly commended for its thoroughness and clarity of style, which, together with its adequate diagrams and illustrations, make it readily understood.

In addition to chapters on cylinder, valve and circuit design, there are chapters on hydro-pneumatics, circuit troubleshooting, pressure-sensitive devices, etc. It will be of particular interest to jig and tool designers, production and methods engineers. *J.A.C.*

Handbook on Electroplating *19th Ed.* (*W. Canning & Co., 30s.*)

This new edition is conveniently divided into three sections; namely, polishing, electroplating, bronzing and lacquering. The book offers an extremely comprehensive survey of the equipment and techniques involved in each type of process. Of particular interest are the tables which list possible faults, nature of the defect, its cause and suggested method of correction. Safety precautions are also covered and formulæ are given from which various plating solutions may be made.

An Outline of U.S. Patent Law. *By Brink, Gipple and Hughesdon.* (*Interscience Publishers Inc., 57s.*)

This is not one of those law books which can be read as literature: as a book, it is hardly one to be read at all. But the very format which renders it unreadable is itself a factor to make it of value to any inventor who, applying for a patent in the U.S., would prefer to understand the procedure for himself rather than rely entirely upon professional advisers. In the same way it will be of use to British and other patent agents who need a readily available reference book on U.S. patent law and procedure.

About two-thirds of the book consists of the texts of the U.S. Code Title 35, which corresponds with our Patent Act, and of the official Rules of Practice. The original portion of the book is that which precedes and introduces these, occupying about one hundred pages and presenting in note form in logical sequence, marginally indexed to the relevant clauses in the "Title" and the Rules, every successive step in the application for a patent, its defence and, if necessary, amendment. The book contains also a chapter on foreign patents (i.e., other than U.S.), but this is so brief as to be of little practical use. It is, however, of some interest as showing the difference between the U.S. law and our own.

Of these differences, the two most important are the absence in the U.S. of the requirement, as in our system and that of many other countries, that a patent be "worked", and the absence of any provision for an "opposition period" between publication and grant. Because of this latter difference, it is clear that the U.S. examiner is called upon to be more exacting and vigilant than the examiner under our own system, the more so since the U.S. law does not provide for the revocation of patents once granted. The chapter on "Negotiation with the Examiner" emphasises the elaborate and sometimes recondite rules applying to the examination. A feature of the U.S. system unfamiliar to us is the complicated action known as "interference" whereby, within the U.S. Patent Office and at its investigation, the applicants for patents which appear to cover substantially identical ground are enabled or required to contest each other's claims. This action is necessary, because the U.S. patent law does not give to the application date the same absolute significance as does our own law. *A.H.B.*

British Semiconductor Guide, 1960. (*Heywood & Co. Ltd., 5s.*)

With the rapid increase in the use of semiconductors, this guide becomes an essential aid to the designer in his selection of either a suitable type, or a reliable manufacturer. It brings together in a conveniently concise form essential technical details of all the principal products of the British semiconductor industry. As a further aid to selection of a transistor for a particular application, an equivalent classification chart is included. Also of interest will be two articles, one a technical assessment of the properties and uses of valves and transistors, and the other, transistor parameters and specifications.

OTHER BOOKS RECEIVED

Introduction to Plastics. (*Rubber & Technical Press, 20s.*)

Standards in Electrical Insulating Materials. (*A.S.T.M., $8.75.*)

Corrosion and Deposits in Coal- and Oil-fired Boilers and Gas Turbines. (*Pergamon Press, 50s.*)

Marine Design Manual for Glass-reinforced Plastics. (*McGraw-Hill, £5 16s. 6d.*)

"Mechanical World" Year Book. (*Emmot & Co., 5s.*)

"Mechanical World" Electrical Year Book. (*Emmott & Co., 4s.*)

Small Gas Turbines and Free-piston Engines. *By A. W. Judge* (*Chapman & Hall, 48s.*)

Exploding Wires. *Edited by Chace and Moore* (*Chapman & Hall, 76s.*)

Torsion Devices. *By P. J. Geary* (*Brit. Scientific Instrument Research Assoc., 21s.*)

Design of Welded Pipe Fittings. By *P. H. R. Lane and R. T. Rose.* (*B.W.R.A., 15s.*)

Ironfoundry Handbook. (*Standard Catalogue Co. Ltd., 42s.*)

Chemistry for Engineers. *By Edward Cartmell.* (*Butterworth, 25s.*)

British Engineers' Handbook. *31st Edition.* (*British Engineers' Assoc., 21s.*)

Metal Industry Handbook and Directory. *49th Edition.* (*Iliffe, 21s.*)

SUB-ZERO TEMPERATURES FOR MATERIALS PROCESSING

STABILISATION of metals, expansion assembly, gas dehydration and biological storage are a few of the many industrial applications involving the use of sub-zero temperatures that have been perfected in the last twenty years. Today this process holds a prominent position in the long list of common industrial operations, and increasing numbers of manufacturers are realising its importance, both in overcoming production problems and in producing better products.

Farnell Instruments Ltd., who are the sole agents for Cincinnati Sub-Zero Products, recently released an interesting paper on the uses of sub-zero temperatures. The greatest call for sub-zero equipment is in the metal-working industry, particularly by manufacturers of steel products requiring exacting tolerances. In its heat-treated form steel is not completely stable. All steels retain a certain amount of austenite after routine heat-treating procedures. When steel is heated to above its critical temperature, the carbon, iron and alloying elements dissolve into a solid solution of austenite, a relatively soft, tough and unstable structure. During quenching this austenite is partially transformed into martensite, a tougher and more ductile substance. While complete transformation from austenite to martensite during the quenching and tempering cycle is the ideal condition, even with good control, as much as 10 per cent austenite may be retained in the steel. This retained austenite will continue its transformation to martensite following heat treatment; that is to say, the steel will age and most important is the fact that during transformation the steel may warp, grow and distort because austenite has a smaller volume per unit weight than martensite. Therefore, it is obvious that complete transformation in the shortest possible time is most desirable and one method of doing this is with the use of sub-zero equipment. The natural ageing process of several years can be accelerated to a matter of a few hours.

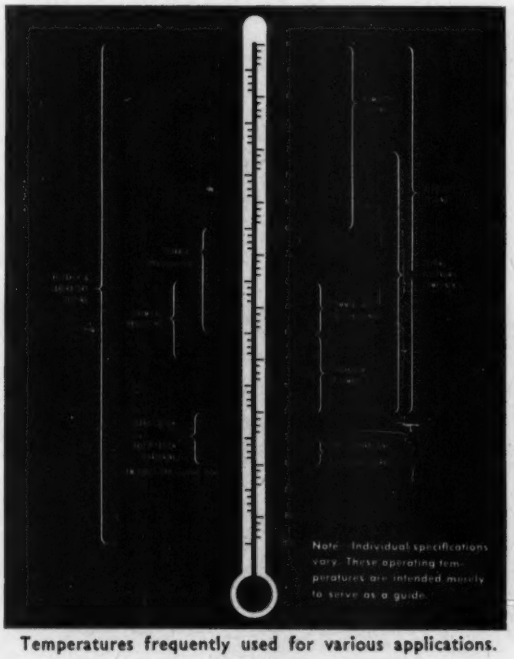
In steel products this quick ageing and hardening process has many applications. Bearing components when stabilised at −90 deg. C. will permanently hold precise tolerances and assure the lowest possible coefficient of friction. Stainless steel aircraft parts, when chilled to −70 deg. C. after annealing and prior to tempering, will achieve greater hardness and result in reduced fabrication time. Hacksaw blades have given more than 113 per cent longer life following treatment at −85 deg. C.

Similarly, aluminium alloys can be normalised through prolonged exposure to sub-zero temperatures. It has been found that very close-fitting aircraft parts machined in the normal manner often seize and fail to operate at high altitudes where extremely low temperatures are experienced. If such parts are frozen to a temperature of between −85 and −100 deg. C. prior to the final machining and lapping, these parts will work freely with much closer clearances during high-altitude conditions. The use of refrigeration to delay the natural age hardening of certain aluminium alloys has greatly speeded production, reduced fabrication costs, and eliminated inconvenient practices. The common practice of shrink-fit assembly is often worked in reverse with the use of refrigeration equipment. The expansion assembly procedure is found to have many advantages over the shrink-fit method, where the high temperatures may cause metallurgical changes, distortion, reduction of hardness, oxidation and general scaling. Shrinking of metal with sub-zero chilling equipment has made it possible to assemble sleeve bearings and ball or roller races otherwise requiring a press fit, by simply slipping them into place after chilling.

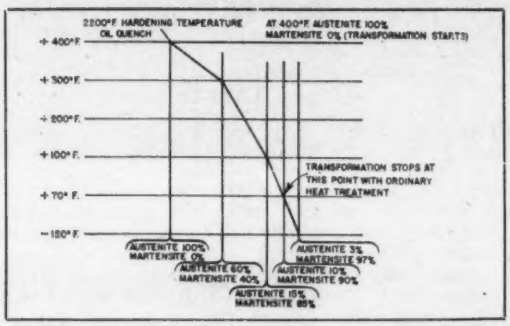
In the manufacture of moulded rubber bushings and similar items, low temperatures have been able to solve a difficult problem in removing flash from moulded parts. These parts are placed in a tumbling barrel and chilled to sub-zero temperatures. At these temperatures the flash becomes brittle and readily breaks away from the body of the part when they are tumbled.

Refrigeration equipment is also used in the manufacture of certain synthetic rubbers. The ingredients of the rubber combine most readily at these low temperatures, and this improved technique has produced synthetic rubber, which, in many respects, is considered superior to natural rubber.

Industrial low-temperature chilling equipment is used also by wire manufacturers as a production testing tool for subjecting insulation to stresses at sub-zero temperatures. Cold equipment is also required in the manufacture of transistors. To stabilise the transistors they are cycled several times from high to low temperatures. An unusual use for sub-zero temperatures has been reported by manufacturers of aircraft instruments. To prevent "snowing" and frost in instruments subjected to low temperatures, the gases used to fill the instrument cases are dehydrated with special refrigerator equipment.



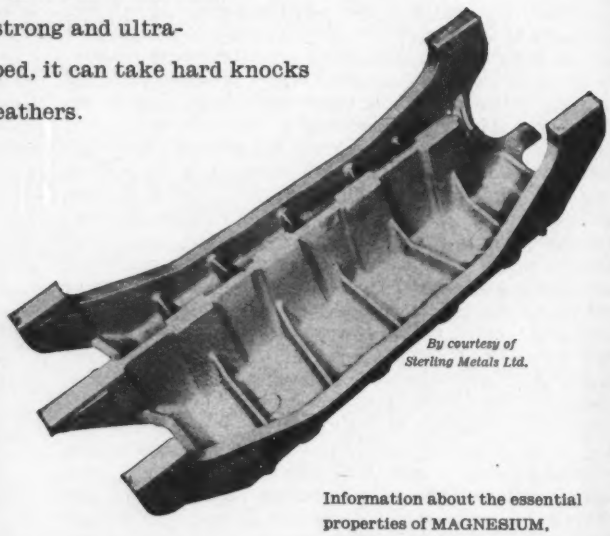
Temperatures frequently used for various applications.


2200°F HARDENING TEMPERATURE OIL QUENCH
AT 400°F AUSTENITE 100% MARTENSITE 0% (TRANSFORMATION START)
+ 400°F.
+ 300°F.
+ 200°F.
+ 100°F.
+ 70° F.
− 150° F.
TRANSFORMATION STOPS AT THIS POINT WITH ORDINARY HEAT TREATMENT
AUSTENITE 100% MARTENSITE 0%
AUSTENITE 60% MARTENSITE 40%
AUSTENITE 15% MARTENSITE 85%
AUSTENITE 10% MARTENSITE 90%
AUSTENITE 3% MARTENSITE 97%

The above chart was developed to show the curve of transformation of austenite to martensite in high-speed steel.

Because the Rotaped half-track unit is shod with track links gravity die cast in lightweight magnesium, it can work without bogging down over soil too soft for a wheeled tractor. By halving and spreading the weight, the links also minimize soil compaction. The Rotaped operates in all conditions over every type of land. Magnesium alloy was chosen because it is strong and ultra-light. Like the Rotaped, it can take hard knocks and rough it in all weathers.

MAGNESIUM SPEEDS THE PLOUGH



By courtesy of Sterling Metals Ltd.

Information about the essential properties of MAGNESIUM, and advice on how this metal can best be converted into popular products, is always freely available from MEL—pioneers and sole producers of Magnesium in Great Britain.

make more of magnesium

Magnesium Elektron Limited

Clifton Junction Manchester Swinton 2511
London Office: 5 Charles II Street St. James's SW1 Trafalgar 1646
Magnesium Elektron, Inc., New York 20, USA

WHAT'S NEW IN MATERIALS & COMPONENTS

Araldite-based Silver

It is announced that research work carried out in collaboration with CIBA (A.R.L.) Ltd. has led to the development of two additions to the JMC range of thermo-setting silver preparations. Both these preparations are based on Araldite.

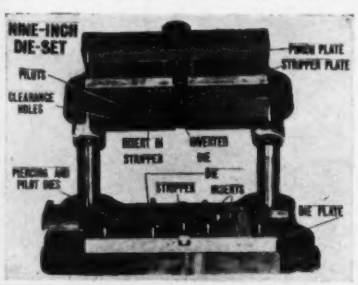
FSP43 is a surface-coating preparation for application by brushing: FSP49 is a conducting cement. Each is supplied in the form of two separate components which are mixed together immediately before use.

The mixed components must be cured at a minimum temperature of 80 deg. C. and will adhere to most materials that are capable of withstanding this temperature, including glasses, ceramics, graphites and many plastics. The films, after curing, are said to be extremely hard, to have high electrical conductivities and to be highly resistant to water and organic solvents. Moreover, the film produced by FSP43 can also be electroplated in many conventional acid baths. Johnson, Matthey & Co. Ltd., 73-83 Hatton Garden, London, E.C.1.

EMD 3201 for further information

Tool and Die Steel

Precision ground tool and die steels in the standard sizes specifically required by the progression tooling industry are now



available. The use of these materials is said to show substantial savings over the use of conventional black bar. The tools shown in the accompanying-photograph supplied by Aerial Pressings Ltd., of North Street, Ilkeston, who are experts in progression tooling and mass-produce small pressings for the radio and television industry, are example of the uses to which Crusader brand steels are put. In the 9-in. die set, which produces stampings from brass coil, the ¼-in-thick stripper plates and the die inserts are made from ground flat stock. The round dies and guide pins, the pilots and the piercing punches are made from ground round stock. George Sorby Ltd., Argus Steelworks, Sheffield, 4.

EMD 3202 for further information

Resin-removing Cream

Synthetic resins and glues are being used increasingly in many branches of industry; workers find that they adhere tenaciously to the skin and are difficult to remove from the hands after work. To overcome this problem a resin-removing cream has been developed. This is said to remove rapidly and effectively epoxide, urea/formaldehyde, polyester, polyamide, phenol/formaldehyde, polysulphide, silicone and other synthetic resins from the skin. The cream is rubbed thoroughly over the contaminated area until the resin is loosened and then wiped off with a clean cloth or washed off with water. In normal circumstances one application is usually sufficient to remove the resin adhering to the skin, but if there is gross contamination a further application may be necessary. Resin-removing cream is said to be non-abrasive and harmless to the skin and it can therefore be used with absolute safety. The cream is available in containers of 1 lb., 7 lb. and 14 lb. Rozalex Ltd., 10 Norfolk Street, Manchester 2.

EMD 3203 for further information

Aluminium Pre-treatment

To meet the industrial demand for treatments for the satin-etching of aluminium, two treatments known as Walterbryte H (heavy) and Walterbryte B (light) have been developed. They are immersion treatments which etch the aluminium surface to give a bright satin or silver appearance, at the same time removing extrusion and drawmarks or other surface defects. For the heavy treatment the operating temperature is 50 deg. C. with an immersion time of 5 min. The light treatment is normally operated at 30 deg. C. with a similar immersion time. These processes produce a decorative effect by etching, and they should normally be followed by a protective treatment such as anodic oxidation or a chemical chrome treatment. The Walterisation Co. Ltd., Purley Way, Croydon.

EMD 3204 for further information

Solventless Epoxide Coating

A solventless liquid epoxide/hardener system which is said to provide a coating of up to 0·010-0·15 in. thick in one application, thereby eliminating the need for costly multiple coats, has been developed. Such coatings are specially suited for application to structural steelwork, most metals, wood and concrete.

In this system, in which pigments can also be incorporated, the hardener cures the epoxide resin under widely varying conditions of temperature and humidity to give hard, tough and chemically resistant films. The thickness of such films can also be varied by incorporating differing amounts of filler into the resin/hardener mix.

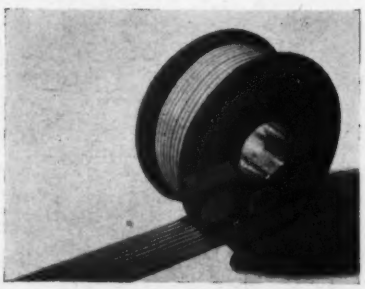
Another important feature of the system is that, by careful formulation, minimum drainage of films on vertical surfaces has been achieved. Flow-out is said to be excellent and the films will harden overnight under normal ambient conditions. Bakelite Ltd., 12-18 Grosvenor Gardens, London, S.W.1.

EMD 3205 for further information

Rubber Sealing Strip

A new synthetic rubber joint sealing strip is now available and is known as 3M Brand "Ribbonseal" pre-formed joint sealing strip; it has been used successfully over many years by the building industry in Canada and the U.S.A.

It is stated that the strip will provide an effective and durable weatherproof seal in joints where tolerances can be closely controlled. It is claimed that it is composed entirely of solids, will not shrink, is



non-inflammable and non-toxic, and will not craze plastic surfaces; also that it has excellent resistance to sunlight, ultra-violet light, ozone, salt spray, moisture and extreme climatic conditions.

It is recommended for use as a glazing or spacer seal, e.g., between glass and rebate, between in-fill panels, lap joints of asbestos sheeting, roof lights, trunking and ductwork, between metal assemblies or as a seal in double glazing units. Where resistance to solvents and oil is required, the manufacturers can offer a pre-formed joint sealing strip known as EC.1126. 3M Company, 3M House, Wigmore Street, London, W.1.

EMD 3206 for further information

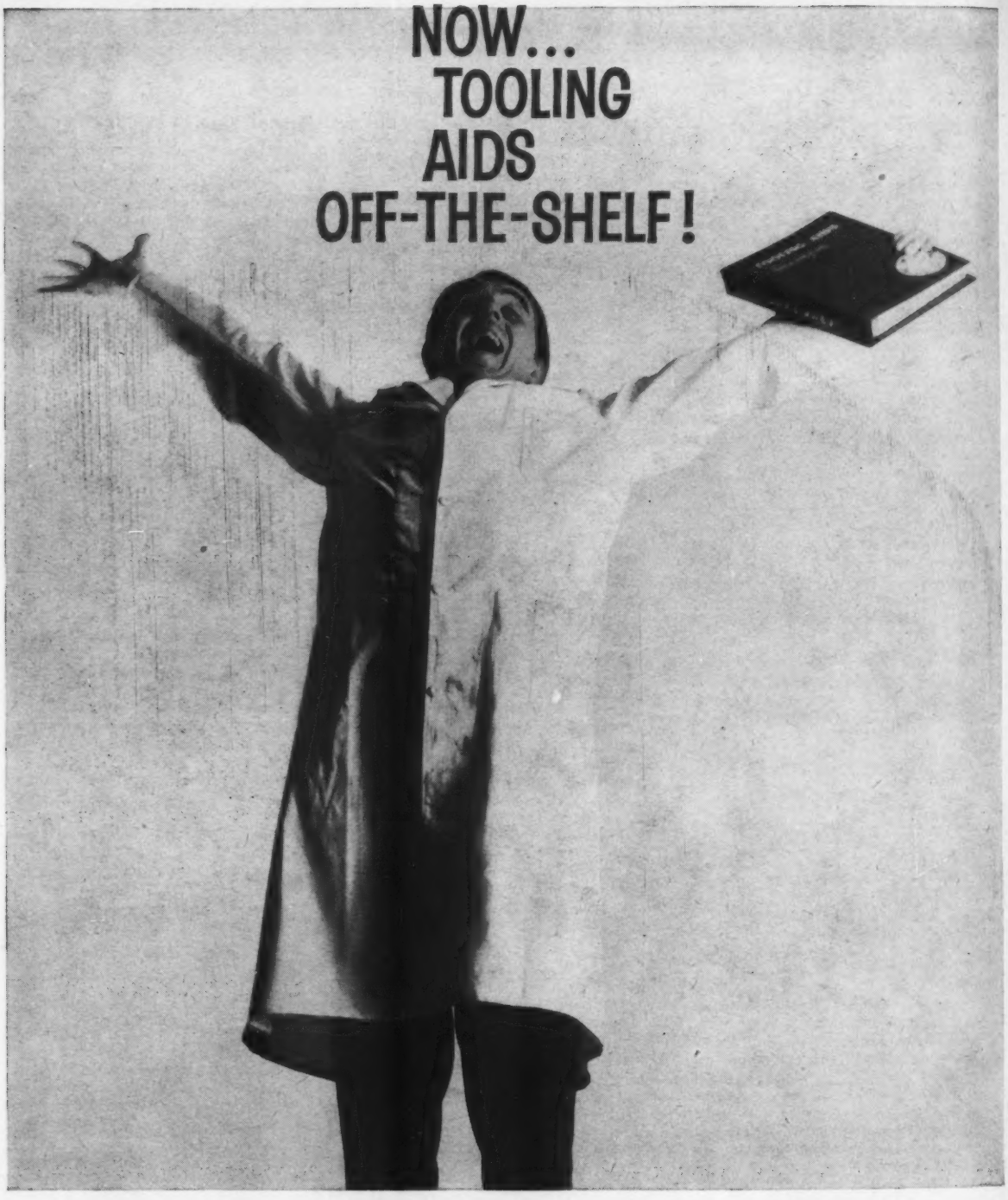
Premium Grade Carbide

Designated Wimet XL35, a new grade of carbide combining to an unusual extent the characteristics of wear resistance and toughness, has been developed for milling steel. Despite its high hardness of approximately 1,500 V.P.N., it is said to possess a superior resistance to thermal cracking at the cutting edge, which has been achieved by the selection of correct grain structure. It is especially suitable for all face, slot and end milling operations on steel. These types of operation cause the greatest thermal shock, because the cutting edge of the tool is heated rapidly to a high temperature whilst cutting, and suddenly cooled whilst passing through air. These tendencies are increased in operations such as slot milling, where the chip thickness tapers to zero and a rubbing action accentuates these effects. It can also be used with advantage, it is said, on other operations such as intermittent turning, where thermal shock is encountered. Wickman Ltd., Coventry.

EMD 3207 for further information

EMD 3121 for further information

NOW... TOOLING AIDS OFF-THE-SHELF!



Yes, this is the way Woodside supplies them. What's more, you can choose *all* your tooling aids from the Woodside Tooling Aids Catalogue as you sit at your desk. Woodside off-the-shelf service means that the tooling aids you need are already made, just waiting to be despatched, so you get extra quick delivery. Quality is the highest attainable . . cost surprisingly low. And just one other thing. If you haven't got your Woodside Tooling Aids Catalogue yet, now's the time to ask for it.

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Woodside Die Sinking Company, Aire Vale Works, Newlay, Leeds. 13.
Telephone No. Horsforth 4251/4 Telegrams: Wooddie. Leeds. Telex No. 55185

A RCC Company

Concrete Waterproofer

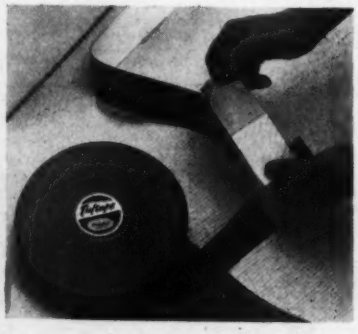
A new waterproofer for concrete products, Durham Duroseal, an aluminium stearate, is a creamy-white free-flowing powder which is easily dispersed in the concrete mix to form an effective waterproofing agent. The advantages claimed for an integral waterproofer is that the material is dispersed throughout the mix at the time of manufacture and consequently the concrete products have a longer life and a greater resistance to water and they are not affected by erosion or cleaning of the stone facing. A reduction in water absorbency of many times that of untreated material is claimed, and the drier the original mix the more marked is the advantage of using Duroseal.

Durham Duroseal has a bulk density of approximately 18 lb./cu. ft. and is packaged in multiwall paper bags containing 56 lb. Durham Raw Materials Ltd., 1-4 Great Tower Street, London, E.C.3.

EMD 3208 for further information

Adhesive Tape

Tuftape is a plastic adhesive tape recommended for a very wide range of applications. The removable plastic gauze protects the adhesive side for easy handling and the tape is available in 2-in. widths and six colours. It can be obtained in any length required. It is claimed to be waterproof. Copydex Ltd., 1 Torquay Street, London, W.2.



EMD 3209 for further information

High-strength Steels

A new series of ultra-high-strength steels for use at high temperatures has been developed to give tensile strength of between 100 and 140 tons per sq. in. after tempering at up to 600 deg. C. In addition to permitting higher operating temperatures to be considered in design compared with steels which are currently being specified for these strength levels, the high tempering temperature is said to yield maximum stress relief and, therefore, greater dimensional stability.

There are at present three steels in the new series, of which the first is a commercial alloy already in production. This was formerly described as Fox 769, but has now been renamed HST 100.

Two entirely new steels in the series have been obtained by small compositional changes in the basic HST 100 analysis, but there is no increase in the carbon content, while use has been made of a combination of solution hardening and improved tempering resistance. The steels are known as HST 120 and HST 140, and are said to have tensile strengths of 120 and 140 tons per sq. in. respectively at room temperature. It has been possible to reduce the carbon content of HST 120 to 0·30 per cent. Both these steels can be hardened in either air or in oil, depending on mass, and all three in the series have silicon contents below 0·40 per cent.

Applications for the HST steels are expected to be found in the aircraft and rocket industries, although HST 140 could probably be used to advantage as a hot die steel. Samuel Fox & Co. Ltd., The Mount, Broomhill, Sheffield, 10.

EMD 3210 for further information

Heat-transfer Medium

Dowtherm A is a clear, light, straw-coloured liquid which is a eutectic mixture containing 26·5 per cent diphenyl and 73·5 per cent diphenyl oxide. The mixture freezes at approximately 12 deg. C. and the compounds do not separate on boiling. Its atmospheric boiling point is approximately 257 deg. C. and it is not normally recommended for temperatures above 400 deg. C. A second material known as Dowtherm E has an atmospheric boiling point of 179 deg. C. and is a specially treated grade of o-dichlorobenzene. This material is recommended for use only at temperatures below 260 deg. C. where the vapour pressure is 72 p.s.i. Dow Chemical Co., 48 Charles Street, London, W.1.

EMD 3211 for further information

"Plastic Aluminium" Liquid

A new addition to the range of Devcon plastic metal products is Devcon F.2, which is Devcon F, the "Aluminium Putty", in liquid form. F.2 has been developed for all those applications where an aluminium material of liquid consistency is required.

Except that Devcon F.2 is a liquid and Devcon F is a putty, these two compounds —80 per cent aluminium, 20 per cent plastic—are identical in composition and behaviour. Both these aluminium compounds are prepared for use in the same way: the hardening agent is mixed thoroughly with the Devcon, and the resultant mix is then ready for use, the liquid form taking a little longer to "set" than the putty form.

Devcon F.2, like Devcon F, is claimed to set to a hardness of 93 on the Rockwell F Scale in approximately 2 hr. at a temperature of 70 deg. F., with an ultimate tensile strength of 8,500 p.s.i. and an ultimate compressive strength of 20,000 p.s.i. Once hardened, Devcon F.2 can be drilled, tapped, filed, sanded, etc., and, it is said, can be worked easily with all normal hand tools. Foley-Brickley & Partners Ltd., 99 Park Lane, London, W.1.

EMD 3212 for further information

P.V.C. Copolymer Foil

"Flovic" p.v.c. copolymer foil is a vinyl chloride acetate copolymer rigid calendered foil, completely without plasticiser, and it is said to give excellent definition using the usual vacuum-forming techniques. It is available in two grades, Opaque White 031 (unsuitable for contact with foodstuffs) and Translucent White 037 (suitable for illuminated ceilings.) White 031 is available in standard thicknesses from 0·01-0·03 in. and widths can be supplied up to 50 in.; it is also available in colours on request. The White 037 grade, intended primarily for lighting applications, has been formulated so that the light transmission is approximately 50 per cent in each thickness. Thicknesses vary in this grade from 0·007-0·025 in. I.C.I. Ltd., Templar House, 81-87 High Holborn, London, W.C.1.

EMD 3213 for further information

Paint for Rusty Steel

A primer known as Sylrust is intended for rusty surfaces and enables such surfaces to be painted with any normal type of paint without the danger of rust breaking through the paint film. It is available in either red or aluminium. In application, loose rust should be brushed off and the primer applied sparingly. It takes approximately 24 hr. to dry under normal conditions and after this any type of topcoat paint can be applied. The operation of the primer is said to depend on the use of an oil with extremely high penetration and which will only oxidise to a limited extent. It is said that the corrosion elements are completely penetrated and the film remains permanently flexible. For this reason it will not dry to a completely hard finish. The Sylglas Co., 81 Knight's Hill, West Norwood, London, S.E.27.

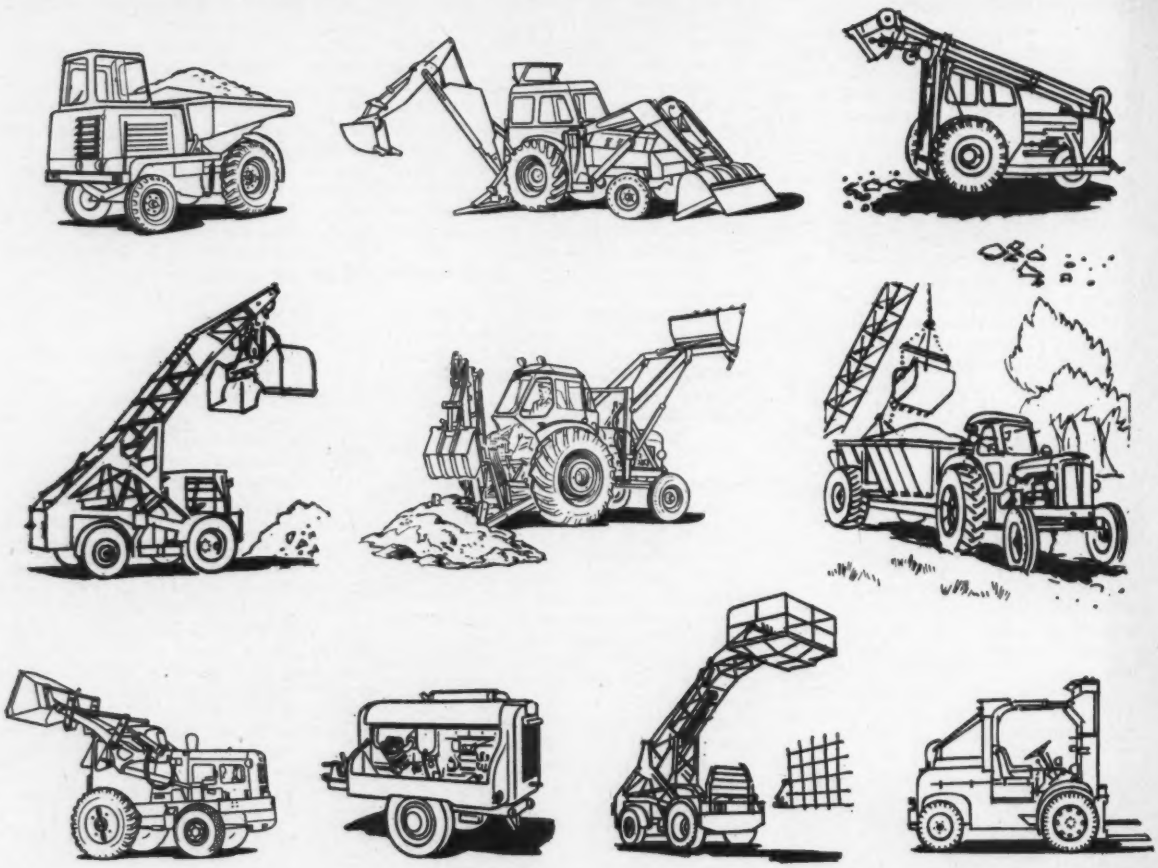
EMD 3214 for further information

Thermosetting Adhesive

A new thermosetting adhesive, Silverlock F100, designed specifically for bonding p.v.c. compounds—either in the form of a plastisol or a calendered film—to steel and other metals has been announced. It is claimed to be the first successful adhesive available in this country for bonding plastisols to steel, opening the way to a cheaper process for coating sheet steel for applications where plain colours are acceptable. Complex metal shapes normally coated with plastisols may now be bonded, thus increasing the efficiency of the coating.

It is said that steel sheet bonded to a 0·010-in.-thick coating of plastisol may be elongated 35 per cent without weakening the bond or damaging the vinyl coating. The adhesion will therefore permit steel sheet to be vinyl coated, embossed and then drawn deep into complicated shapes without ruining the adhesion. The adhesive is a low-viscosity, solvent-based type and may be applied by spray, brush, float or roller to metal. After air drying, the adhesive is prebaked and the plastisol is then applied and gelled in the normal way. In cases of vinyl sheet, slight laminating pressure should be used and the metal temperature should be 300-365 deg. F. B.T.R. Industries Ltd., Herga House, Vincent Square, London, S.W.1.

EMD 3215 for further information



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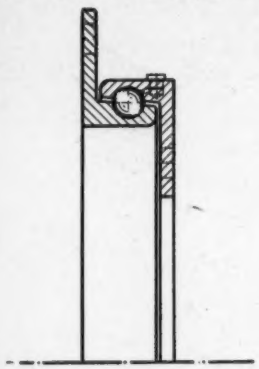
WISE BUYERS INSIST ON FORDSON POWER

INDUSTRIAL SALES DEPARTMENT TRACTOR DIVISION FORD MOTOR COMPANY LIMITED DAGENHAM ESSEX

Ball-bearing Turntables

An inexpensive range of single-row turntable bearings, particularly suited to

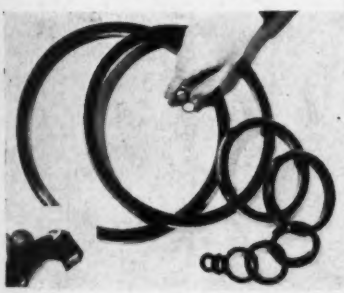


the requirements of turntable truck makers, but having many potential uses, such as large stationary turntables and for making up welding positioners and like equipment, is now available. The bearings are made from medium carbon steel sections which are cold bent to the correct diameter and then welded. They are capable of catering for both end thrust and tipping moments. Diameters range from 16 in. to 41 in. Roballo Engineering Co. Ltd., 43 Dover Street, London, W.1.

EMD 3216 for further information

New Seal Range

Bal-Seles are precision-moulded oil-seals designed to reduce the risk of extrusion under pressure and they are made of Hycar nitrile rubber. They are of one-piece construction and the solid construction and flared walls are claimed to pro-



vide a positive yet resilient fit on rods and cylinders.

Resistance to extrusion is achieved by using a fabric base which also reinforces the seal at the point at which stress and pressure are concentrated. The seals are said to be easy to handle and can be stored and fitted without fear of damaging or distorting the sealing lips. B.A.L. Ltd., Dudley, Worcestershire.

EMD 3217 for further information

Screwless Terminal Block

The problem of wires coming adrift from terminal blocks by vibration is claimed to have been solved by the screwless spring-grip terminal block. In this component the wire is gripped by the force of a strong spring, yet finger pressure only is said to be necessary to compress the spring and release the wire. No tools are necessary and the joints are claimed to be absolutely firm. The assembly is claimed to be able to withstand a flash test of 5 kV. a.c. r.m.s. for one minute between the connections and earth. The terminal block can be supplied in a self-contained form for fitting into housings, panels or printed circuits, or with 2, 3, 4, 6, 8 or 10 pole terminal bar with solder tongue connections on one side, or as a multi-pole through-way terminal with double-sided connections. Each terminal is suitable for connecting to wire or stranded cable as desired and will accommodate sections from 1/0·004 to 3/0·036. Engels & Gibbs Ltd., Warwick Road, Boreham Wood, Herts.

EMD 3218 for further information

Small Air Cylinders

A new range of air cylinders of 1-in. and 1¼-in. bore sizes is announced by Air Automation. These inexpensive cylinders are of non-ferrous construction with stainless-steel piston rods, screwed nose mounting and rear trunnion mounting. High-quality synthetic rubber seals (not O rings) on a non-ferrous piston are used and the series is available in single- and double-acting non-cushioned patterns. End caps are round to enable the cylinders to be used in confined spaces. Air Automation, 26 Sharrocks Street, Wolverhampton.

EMD 3219 for further information

New Hydraulic Wheel

A simple and efficient means of driving pedestrian- and rider-controlled trucks of all descriptions is provided by the hydraulic wheel, a slow-speed, high-torque hydraulic motor with a stationary shaft and rotating crankcase which fits inside 12-in. diameter tyres. The standard model develops a drawbar pull of 500 lb. when working at 4,000 p.s.i., sufficient power for a truck of 3 tons capacity. The motor efficiency is stated to be 94 per cent.

Simplicity is the main feature of this unit in which braking is automatic and

which provides any speed between 0 and 500 r.p.m. in either direction by operation of a single control lever. Smooth "inching" and creep speeds are said to be readily obtainable. The prime mover can be petrol or diesel engine, battery- or mains-operated electric motor. Hydrostatic Transmissions Ltd., 33 Balfour Grove, London, N.20.

EMD 3220 for further information

Miniature Rectifier

A new range of silicon-controlled rectifiers is announced. The new device is of the P-N-P-N form and can be regarded as two transistors coupled by a common collector junction; it is the solid-state equivalent of the thyratron or the grid-controlled mercury-arc rectifier. It offers a high impedance (several megohms) in each direction, but can be triggered into a low impedance condition in one direction by the application of a small signal to the third electrode. It has the usual

solid-state advantages of small size and absence of heater supplies, and has, it is said, a high efficiency of operation.

Applications are similar to those of the conventional devices, such as the control of electric motors, firing of ignitrons, D.C. to A.C. conversion, frequency conversion, phase-controlled D.C. power supplies, static switching, etc.

Loads up to 10 amps. at 25/300 volts peak inverse voltage can be handled. Associated Electrical Industries Ltd., Electronic Apparatus Division, Rugby.

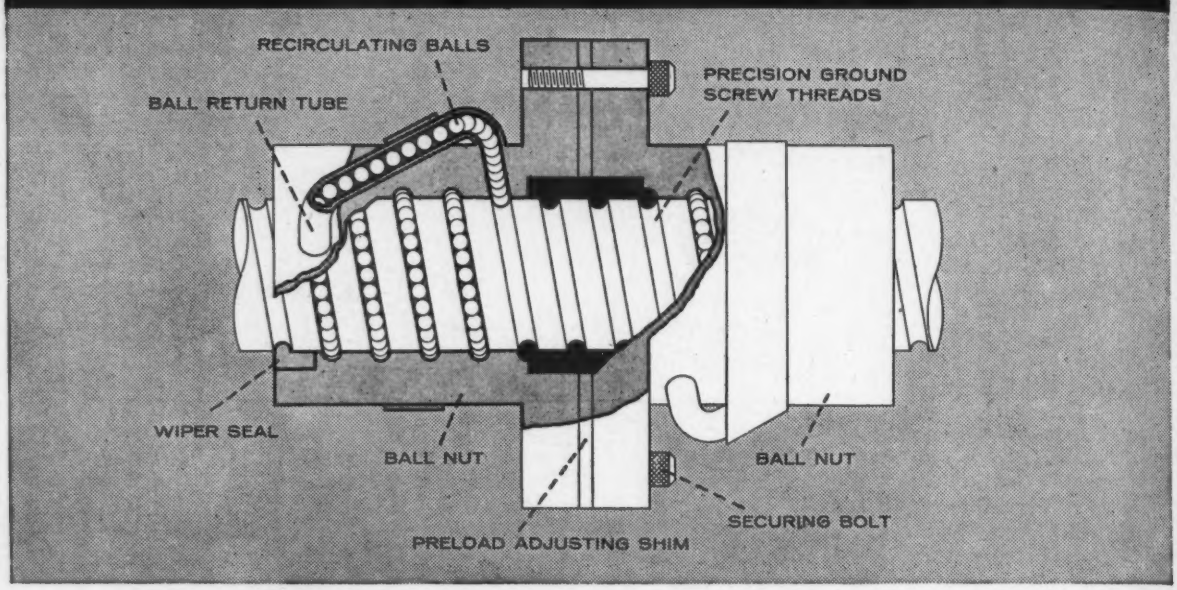
EMD 3221 for further information

Bellows Expansion Pipe Joints

Genflex bellows expansion joints enable the expansion and contraction of pipe systems due to temperature changes to be absorbed without recourse to expansion loops, with their attendant bulkiness and expense of installation. The new unit is said to be compact, flexible and designed to absorb vibration and movement in all planes.

The standard bellows is produced from 18/8 cold-rolled stainless-steel sheet, welded into a tube with a longitudinal butt weld under accurately controlled conditions, the weld being the same material thickness as the adjacent metal. Convolutions are then formed on special machines.

Beaver pre-loaded ball screws, up to 95% efficient, operate at -52°C to over 400°C with no backlash...



...ANOTHER ENGINEERING ADVANCE FROM BRISTOL SIDDELEY

Bristol Siddeley Engines Limited produce Beaver* pre-loaded ball screws. These ball screws achieve a minimum efficiency of 90% and they can operate within a temperature range of −52° C to 400° C without lubrication, and up to 170° C when lubricated.

Machined and ground to the highest standards of precision engineering Beaver pre-loaded ball screws greatly increase transmission efficiency. They reduce the power required for actuation by as much as 80%, when converting rotary drive into linear output or force input into torque output. By eliminating backlash, with pre-loading, they give precise control over very small increments of motion and a high response frequency. And when compared to conventional screw mechanisms, they provide a predictable operating life which is much longer, require much less maintenance and give more trouble-free operation.

Basic design application analysis

Bristol Siddeley engineers make an exhaustive analysis of each specification. And each unit is specially designed for its particular application. Beaver ball screws are made automatically reversible or with controlled "no-back," with multiple or single circuits. Beaver pre-loaded ball screws have been proved as the most efficient method of converting rotary into linear thrust in over 2,700 engineering applications in many branches of industry. They have been designed already with rated operating load capacities of 370,000 lb (825,000 lb maximum static load) but the maximum potential operating load is, in most cases, limited only by the requirement.

Bristol Siddeley Beaver ball splines have been developed to eliminate the disadvantages of conventional splines. The designs are very effective in minimising friction, particularly when high torsional and bending loads are imposed during linear movement.

** Complete technical and manufacturing co-operation with Beaver Precision Products Inc., Detroit.*

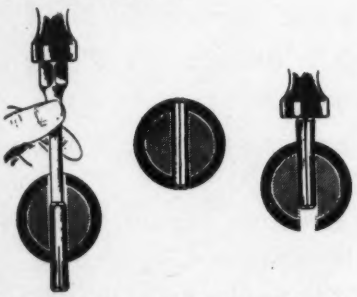
For further information please write to J. B. Starky, Sales Manager (Beaver Products Division), Bristol Siddeley Engines Limited, PO Box 17, Coventry, England.

BRISTOL SIDDELEY ENGINES LIMITED

For special applications Genflex bellows can be made from Nimonic 75 for temperatures over 750 deg. C. and Monel, Inconel and titanium where unusually corrosive conditions occur. Rectangular and other special bellows can be fabricated to large sizes, diameters above 120-in. bore being made to special order. Units are available with all patterns of restraint such as hinged, gimbal, tied or articulated with any type of coupling. Vokes Genspring Ltd., Henley Park, Guildford, Surrey.

EMD 3222 for further information

Slotted Spring Pin



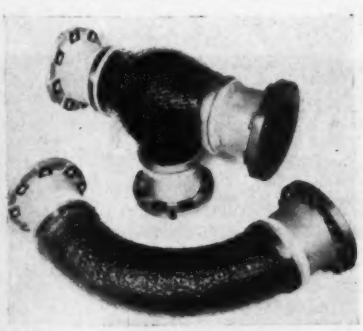
The Rollpin, a slotted cylindrical spring pin which is claimed to replace screws, rivets, solid pins, taper pins, hinge pins, etc., is now being manufactured in this country. The Rollpin is easily driven into a hole where its own tension locks into position. It is said to be unaffected by vibration or movement, yet may be easily drifted out if desired. Its slot dimensions, outside diameter and elastic limits are carefully designed so that the locking action is achieved in holes drilled to production tolerances. For ease of handling it is chamfered at both ends and is suitable for hopper feed. Heat-treated during production, the Rollpin is claimed to have greater resilience and shear strength than the solid pin.

Sizes at present available range from $\frac{1}{16}$ to $\frac{1}{2}$ in. in diameter. The Tempered Spring Co. Ltd., Sheffield.

EMD 3223 for further information

Glass Fibre Reinforced Pipe

Bristol pipe is a complete pressure piping system of thermosetting epoxide resin reinforced with high-strength glass fibres, and is produced in sizes ranging from 6 in. to 15¼ in. bore. The piping is produced in standard 20-ft. lengths, with a standard range of ancillary fittings—tees, bends and flanges. The pipes can be either flange-jointed or bonded: the bonded-joint method is favoured for permanent pipeline installations, a special mobile equipment being available to enable the pipes to be rapidly and efficiently bonded *in situ*.



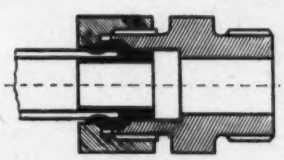
Bristol pipe is claimed to be highly resistant to corrosion and is virtually unaffected by soils, sea-water, demineralised water and the majority of dilute acids and alkalis, even up to temperatures of 120 deg. C. As both pipe material and reinforcing material are non-conductors of electricity, the piping is not subject to electrolytic action and the pipes can therefore be buried in the ground without protective coating or cathodic protection.

The piping is claimed to be one-quarter the weight of steel pipe for the same operating pressures and to be equally strong as steel piping of comparable wall thickness but approximately ten times more flexible. Bristol Aeroplane Plastics Ltd., Filton House, Bristol.

EMD 3224 for further information

Self-sealing Tube Coupling

The Wade self-sealing coupling is claimed to have unlimited use in the compression coupling field and to be simple, effective and cheap to install. All that is necessary is to undo the coupling and pull



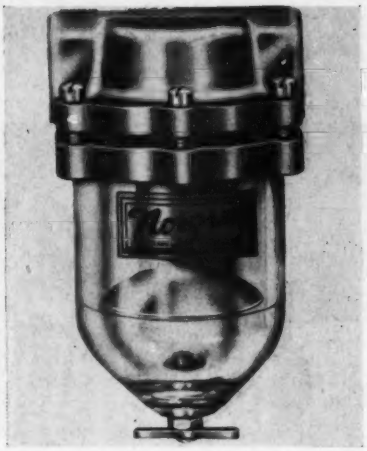
out the pipe. To join it is only necessary to push in the pipe and do up the nut. It is now available for ¼-in. and $\frac{5}{16}$-in. O/D tube × ¼ in. or ½ in. B.S.P. or A.P.I.; or for plastic tubing ¼ in. O/D × ¼ in. or ½ in. B.S.P. or A.P.I. Wade Couplings Ltd., 270 High Road, Ilford, Essex.

EMD 3225 for further information

New Air Filter Range

Greatly increased efficiency is claimed for the new Norgren Series 30AE air filters, available in ¼-in., ⅜-in. and ½-in. pipe sizes. The measurement of this efficiency is that the water passage point (i.e., the point at which the filter ceases to remove the free moisture from the line) is at a flow above that normally recommended as the maximum flow for a ¼-in. pipe.

A choice of three interchangeable filter elements is available; namely, a 64-micron sintered bronze element as standard with a 25-micron sintered bronze element and 74 micron monel wire element as alternatives. The bowl of the filter is available in transparent or metal form, the former allowing full visibility of the need to drain moisture from the filter. the latter being suitable for higher pressures, higher temperatures and rougher usage. C. A. Norgren Ltd., Shipston-on-Stour, Warwickshire.



EMD 3226 for further information

Heated Hoses

Two basic designs of heated hoses are now available which are recommended for the many materials that cannot possibly be pumped unless they are kept above their solidification temperatures. This problem exists for such materials as candle wax, but is also present when materials such as water must be prevented from freezing. The two hoses are known as Heronflex and Evaflow.

Heronflex has two concentric metallic braidings which are used for giving flexible hose a high mechanical strength to resist hard usage. This metallic braiding comprises a large number of wires to which heat is applied over the whole area by means of a current that is of sufficiently low voltage to give no possible risk of shock. The braid structure of the conductor is claimed to permit a high degree of flexing. The braidings are electrically connected at one end and their other ends are connected to the secondary winding of a mains transformer.

Evaflow, the second type, is relatively inexpensive, and instead of braided wire conductors it has two concentric wire coils in the hose walls. These again serve as both mechanical strengtheners and heating elements, but the hose will only withstand a comparatively low fluid pressure and a small amount of flexing. The inner coil has a greater resistance than the outer so that a greater concentration of heat is applied at the inner surface of the hose. Heated Hoses Ltd., Sheffield.

EMD 3227 for further information

Adjustable Oil Feed Indicator

A small and compact oil feed indicator, measuring 4 in. high and 1½ in. diameter, which can be fitted into confined spaces and is yet capable of giving a clear indication of the oil flow has been introduced.

A fine screw thread control enables the oil feed to be readily adjusted from 3 gal./min. to complete cut-off while the system is still running and is claimed to handle pressures up to 125 p.s.i.

50,000

HYDROVANE BULLOWS

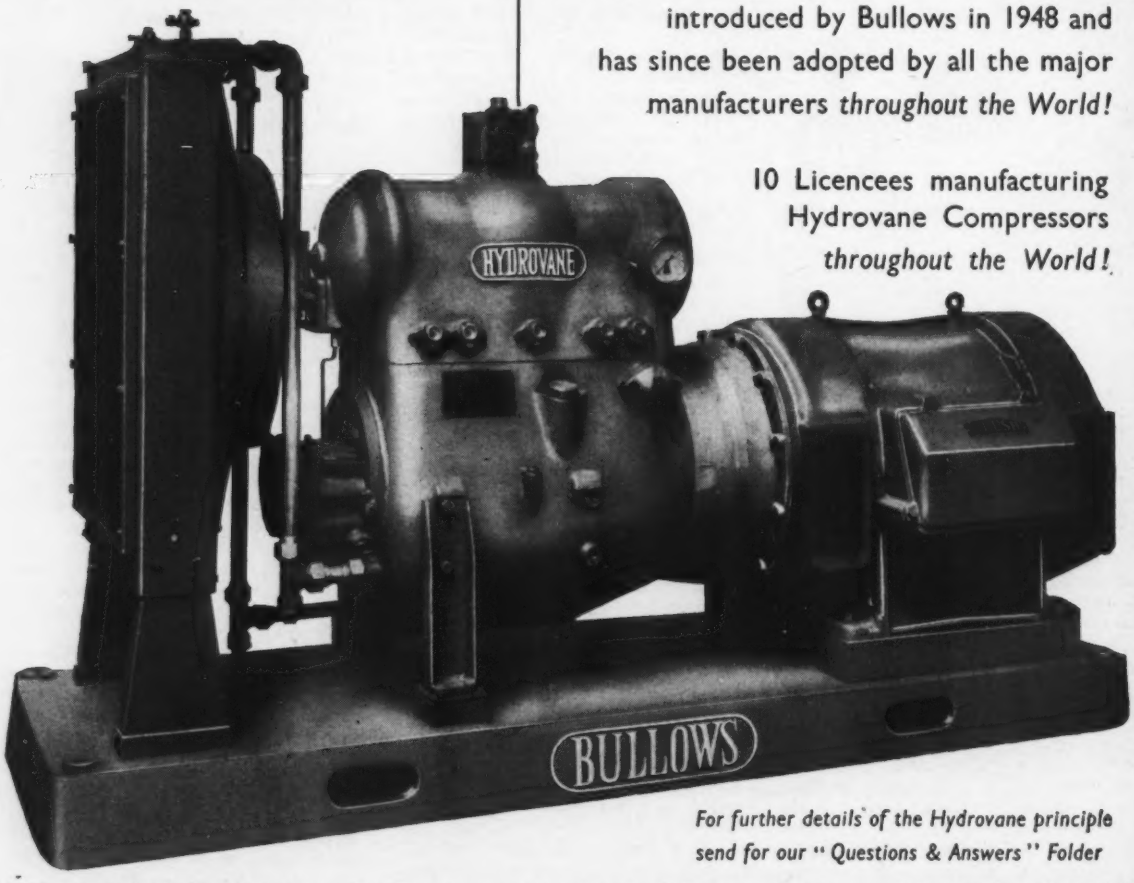
OIL-SEALED ROTARY COMPRESSORS

FROM 1/3-250 H.P.

IN USE *throughout the World!*

The Hydrovane principle was developed and introduced by Bullows in 1948 and has since been adopted by all the major manufacturers *throughout the World!*

10 Licencees manufacturing Hydrovane Compressors *throughout the World!*



For further details of the Hydrovane principle send for our "Questions & Answers" Folder

AIR COMPRESSORS · SPRAY PAINTING EQUIPMENT · SPRAY BOOTHS

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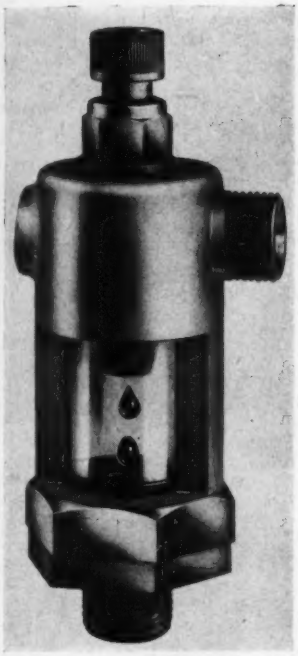
TELEPHONE: SOUTH 2383
TELEPHONE: DUBLIN 73188/9



The body of the indicator is of bronze and the adjustable screw is of hardened steel, cadmium plated. The inlet is ¼ in. B.S.P. male and will fit either standard pipe or flexible hose connections. Outlet is ¼ in. B.S.P. The unit is finished either dull nickel or black wrinkle. Suba Hydraulics Ltd., 86 Lind Road, Sutton, Surrey. **EMD 3228** for further information

New Clutches & Clutch Couplings

A new type of bearing-mounted electromagnetic clutch and clutch/coupling, which is claimed to provide two important advantages over the flange-mounted type, is now available. With the latter it has been necessary for the user to ensure that the field, which carries the coil, is accurately positioned in a concentric manner in relation to the rotor.

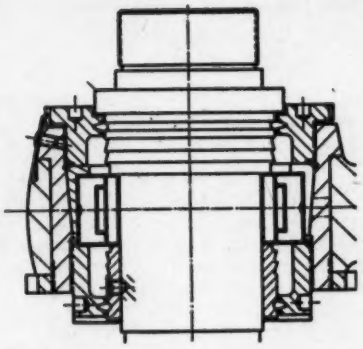
In the new unit the field, which carries the coil, is mounted on the rotor with its own bearing and a torque arm restrains the field from moving with the rotor. Advantages of this design are first that the field is held concentric with the rotor and so eliminates prior assembly by the user, and, secondly, that if the rotor and shaft tend to move due to shaft bearing wear, the field automatically follows and at no time is it possible for the rotor to foul the field.

The new bearing-mounted clutches and clutch couplings have the same maximum static torque as the flange-mounting units. S.F.160: 8 lb. in. static torque. S.F.250: 60 lb. in. static torque. S.F.400: 240 lb. in. static torque. Westool Ltd., St. Helen's, Auckland, Co. Durham.

EMD 3229 for further information

Adjustable Needle Bearings

Nadella Delta needle bearings, developed with the machine tool industry in mind, where the demand for spindle bearings without play are in great demand, feature a unique principle whereby diametrical play can be adjusted to suit operating requirements. Adjustment is achieved by tightening the outer ring, the periphery of which is provided with three



equi-spaced rib-shaped zones. As the outer ring is tightened, it takes a non-circular form due to the three projections, thus reducing play to the desired value, or even imparting a degree of pre-loading.

In these bearings the angular spacing of the rolling components is very small and this fact is claimed to enable spindles equipped with them to give surface finish results comparable to those achieved with spindles running in plain bearings. Insley Industrial Supply Co. Ltd., 21/22 Poland Street, London, W.1.

EMD 3230 for further information

FOR MORE INFORMATION
about any of the products mentioned on these pages, please use the special reply card bound in this issue.

READERS' ADVISORY SERVICE
We shall be pleased to help readers who have difficulty in tracing sources of supply of materials or components.

New Publications and Technical Literature

Barflo Ltd.: Leaflet giving range of sizes and prices of plastic expansion units. 56 Cavendish Place, Eastbourne.

EMD 3231

B.K.L. Alloys Ltd.: A 32-page catalogue (No. 599) of welded fittings, stainless-steel fittings and aluminium fittings. Standard and special-purpose fittings are included as well as specifications for raw materials and selected specifications for low-temperature service. Birmingham Factory Centre, Birmingham, 30.

EMD 3232

W. C. Holmes & Co. Ltd.: Leaflet describing standard automatic bag filters with shaking gear and listing the types available and the range of sizes with their respective capacity. P.O. Box No. B7, Turnbridge, Huddersfield.

EMD 3233

F.T. Products Ltd.: A fastenings manual for designers illustrating forty examples of assembly fasteners with details of the specific purpose for which each was designed. Wallingford Road, Uxbridge, Middx.

EMD 3234

The Pitch Fibre Pipe Assoc. of Gt. Britain: Brochure giving technical data, costs, laying and advantages of pitch fibre pipes. Also range of fittings. 27 Chancery Lane, London, W.C.2.

EMD 3235

Polypenco Ltd.: Leaflet giving guidance on the design of nylon bearings made from Nylon 66 and Nylatron GS. 68-70 Tewin Road, Welwyn Garden City, Herts.

EMD 3236

Rosite Ltd.: Illustrated brochure giving guidance for designers together with data and typical characteristics of Rosite mouldings which are recommended for heat and arc resistance combined with non-tracting properties. Cheney Manor, Swindon, Wilts.

EMD 3237

Royal Worcester Industrial Ceramics Ltd.: Booklet describing Regalox industrial ceramics and including physical properties and other data. Tonyrefail, Glam.

EMD 3238

Rubery, Owen & Co. Ltd.: Leaflet presenting the Ro-plax range of reinforced plastics for domestic, engineering and agricultural uses. Whitegate Factory, Wrexham, North Wales.

EMD 3239

Simmonds Aerocessories Ltd.: 16-page brochure containing details of Nyloc self-locking nuts which are now available up to 4-in. thread dia. in a variety of threads. Treforest, Pontypridd, Glam.

EMD 3240

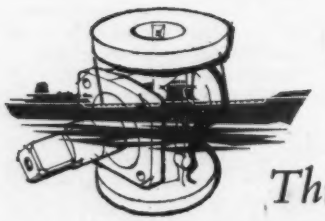
The Standard Piston Ring & Engineering Co. Ltd.: 24-page booklet illustrating the range of piston rings available with notes on the characteristics of each type. Premier Works, Don Road, Sheffield, 9.

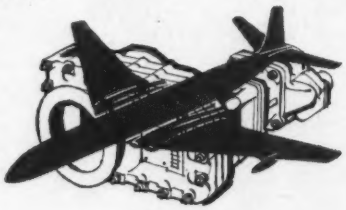
EMD 3241

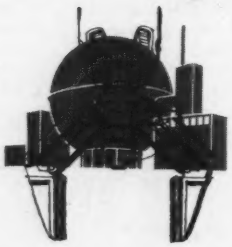
Wray (Optical Works) Ltd.: Leaflet called "Optical Aids" and including binocular magnifier, inspection telescope,, the Wrayflex copying camera, microfilm reader and focusing magnifier. Bromley, Kent.

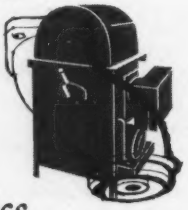
EMD 3242

Kanigen *a hard, non-porous corrosion-resistant plate, gives complete uniform coverage even to the most intricately shaped parts. Thickness can be controlled to fine limits. Being chemically deposited Kanigen can be applied to practically all metals in commercial use. It can also be applied to non-conductors such as plastics and ceramics.*









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TRW/761

News of Industry

The International Congress on Combustion Engines (C.I.M.A.C.) Permanent Committee has agreed that the sixth International Congress will take place in Copenhagen in the week beginning June 18, 1962. The conference theme will be recent developments with diesel engines and gas turbines above 3,000 h.p. per engine and with gas engines above 1,500 h.p. per engine. Preliminary planning has begun and a time-table has been agreed for the submission and acceptance of synopses and papers.

Bristol Siddeley Engines Ltd. announce a licence agreement with Piaggio & C. of Genoa for the manufacture and sale in Italy of the Viper II turbojet. This is the second agreement concluded by Bristol Siddeley with an Italian manufacturer; the Orpheus turbojet is already in production by Fiat, primarily for the Fiat G-91 strike fighter for the N.A.T.O. air forces.

The Viper II, which has a thrust of 2,500 lb., powers the Macchi MB 326 which has been adopted by the Italian Air Force as their standard primary trainer. This turbojet, which has been used in light fighters, mixed power-plant interceptors, missiles and vertical-take-off aircraft, is being further developed with increased thrusts.

An agreement to manufacture flexible ducting was made in record time between the Scottish company of **George MacLellan & Co. Ltd.** and an American company, the result of which was the formation of a new Scottish company, **Flexible Ducting Ltd.** This ducting was originally developed in America as a war-time necessity for the ventilation of merchant and fighting ships, and the new Scottish enterprise will extend its use and application.

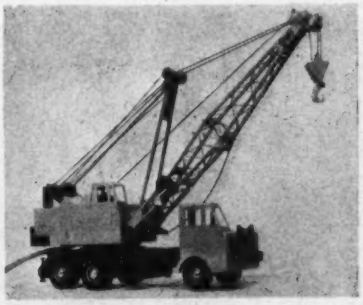
Visitors to the Golden Jubilee Industrial Exhibition at Stoke-on-Trent were able to see samples of precision machined parts, non-ferrous and high duty iron castings up to twenty-five tons in weight manufactured by **T. M. Birkett, Billington & Newton Ltd.**, who also specialise in high tensile aluminium bronze castings, centrifugal castings and shell mouldings. Castings range from a few ounces to 10 tons in a variety of non-ferrous metals.

At this year's National Industrial Safety Conference, organised by the **Royal Society for the Prevention of Accidents**, a paper entitled "The Specialist as Part of the Team" was presented, the theme of the paper reflecting the general tone set by the working sessions of the Conference. The Sir George Earle Trophy for industrial safety achievement was awarded this year to **Associated Electrical Industries (Manchester) Ltd.** in recognition of outstandingly successful efforts to produce safe working conditions and the generosity of the company in making its help and advice readily available.

The 1960 meeting of the Dechema Deutsche Gesellschaft für chemisches Apparatewesen e.V. was recently held at Frankfurt, and represented the 26th meeting of the **European Federation of Chemical Engineering** and the 8th meeting of the **European Federation of Corrosion.** The theme of the Conference was structural material problems in chemical technology and papers reported on experience and progress made in the use of materials for the construction of chemical plant.

To assure the designer that the material will behave as predicted under a given set of circumstances, **Aluminium Laboratories Ltd.** not only have research staff working on physics, chemistry, metallurgy and engineering research, but have departments whose sole function is to evaluate problems that face component manufacturers.

One such department deals with surface finishing, which includes vitreous enamelling, light and fast colour finishes and opaque acid anodising. The electrical department has been working on the use of aluminium foil for transformer windings and on aluminium-cored plastics cables. One interesting project is the design, production, handling, marking and labelling of aluminium cans for the food industry. The evaluation of fabrication and joining methods are further important aspects which are aimed at making aluminium and its alloys still more attractive.



Coles Ranger truck-mounted crane.

At the Annual General Meeting of the **Royal Aeronautical Society**, Mr. Peter G. Masefield, M.A., F.R.Ae.S., Hon.F.I.A.S., M.Inst.T., presented the George Taylor (of Australia) Gold Medal, awarded for the most valuable contribution on aircraft design, manufacture and operation, to R. Hafner, F.R.Ae.S., formerly Chief Designer (Helicopters) Bristol Aircraft Ltd., now Special Director (Bristol) Westland Aircraft Ltd., for his paper "Safe Mechanisms", part of which was given in ENGINEERING MATERIALS AND DESIGN, March, 1959.

At the end of the meeting his successor, Dr. E. S. Moult, C.B.E., B.Sc. (Eng), F.R.Ae.S., M.I.Mech.E., was inducted as President of the Society until May, 1961.

Products shown by **Ferranti Ltd.** at the British Exhibition in New York include a working scale model of an impulse generator, a buried-type distribution transformer and a scale model of a 60,000-kVA., 330-kV., 3-phase power transformer. Instruments will include a Ferranti-Shirley viscometer with automatic flow curve recorder, a portable viscometer of the coaxial cylinder type giving immediate readings of viscosity when the cylinders are immersed in liquids and semi-liquids, and a working demonstration of a peak accelerometer. Other exhibits will be from the computer department, electronics department and aircraft equipment department.

A Coles Ranger truck-mounted crane manufactured by **Steels Engineering Products Ltd.** has been selected by the Council of Industrial Design for inclusion in the British Government exhibit at the Canadian National Exhibition, to be held in Toronto from August 24 to September 10, as being typical of the best in British engineering design and construction.

This heavy-duty crane has a lifting capacity of twenty-five tons at 10-ft radius with a 30-ft centre strut jib. An A.E.C. oil engine powers the truck, crane movements being by diesel-electric.

Sciaky Electric Welding Machines Ltd. have announced the commercial availability of a new-type four-channel spot welder control, of the fully synchronous, digital type, named Synchrospot. The control, claimed to eliminate transients with a considerable reduction in power demand, is suitable for use with any spot or projection welder.

The advantages to be gained from the use of synchronous controls include the ability of this control to permit welding at speeds in excess of 750 spots per minute, each weld time being guaranteed 100 per cent accurate.

A unique demonstration recently presented at **The Institution of Electrical Engineers** by MM. R. Chaste and P. Cassagne described a new system of colour television transmission. Scenes originating in Paris were seen in full colour in London on screens which differed little, if at all, in their external appearance from those of ordinary television receivers. The transmitted pictures were "compatible", which is important, because it provides a means of bridging the gap if a colour service were to be introduced; an existing set would still give a black-and-white result from the colour transmission.

"Design of Anti-vibration Mountings" (K. L. Johnson, ENGINEERING MATERIALS AND DESIGN, Apr. 1960, p. 268). The table of typical values of T_s at the foot of p. 271 is taken from Fletcher and Gent, *Brit. J. App. Phys.*, 1957, vol. 8, p. 194.

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